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ABSTRACT

The development and evaluation of prototype hands-on equipment, job sample performance tests for a high skilled technical Military Occupational Specialty (MOS) are described. An electronic maintenance MOS (26C20) was used as the research vehicle. The results led to the conclusion that valid and reliable performance tests could be constructed, but that equipment, facilities, and standardization requirements reduce the feasibility of their use at other than an ideal location, such as a U.S. Army school. (Author/MV)

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This report describes the development and evaluation of prototype hands-on equipment, job sample performance tests for a high skilled technical MOS. An electronic maintenance MOS (26C20) was used as the research vehicle. The results lead to the conclusion that valid and reliable performance tests could be constructed, but that equipment, facilities, and standardization requirements reduce the feasibility of their use at other than an ideal location, such as a U.S. Army school.

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SUMMARY AND CONCLUSIONS

Military Problem

The US Army has placed emphasis recently on performance-based training and evaluation. Performance-based evaluation, using job sample hands-on equipment, has not been developed or used for complex technical MOSs. Therefore, there is a need to determine the feasibility of developing and using job sample hands-on equipment performance tests for a complex technical MOS.

Research Objective

The research project was to determine whether it was feasible to develop and use hands-on, job sample performance tests for assessing job performance of high skilled electronic maintenance technicians. Feasibility was defined in psychometric and administrative terms.

Method

An electronics maintenance MOS was selected as the research vehicle. An analysis of the job tasks was undertaken to categorize job activities. Performance tests were developed to categorize job activities. Performance tests were developed and experimentally evaluated for selected job activities. The tests were administered to technicians with a broad range of experience. Two scoring approaches were used--a GO/NO-GO product measure and a process measure where task procedures were evaluated. In addition, time-to-perform the test was obtained for each administration of the test.

Results

An approach to selecting job tasks to be used in the performance tests was taken that emphasized content validity. In addition, empirical validation using a mastery classification approach was used. Master/non-master categories were defined using job experience, MOS test scores and job performance rating criteria. Empirical validity was found for two of the three tests using MOS score and for one test using job performance ratings.

An interrater reliability of .73 was obtained for the process measures. There was 100% agreement between raters when the GO/NO-GO scoring procedure was used.

A time limit of 60 minutes was set for each test. Of those who successfully completed the tests in that time limit, no significant relationships were found for the time scores and MOS scores, job experience and job performance ratings.

Conclusions

Valid and reliable performances can be developed for assessing electronic maintenance skill proficiency. However, equipment, facilities and administration standardization requirements may reduce the feasibility of using full hands-on, job sample performance tests at other than an ideal location, such as an electronic maintenance school. The performance tests developed in this research could be used to validate synthetic performance tests in such a setting.

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I. INTRODUCTION

A. Background

Over the last several years as the Army's Enlisted Personnel Management System (EPMS) has developed, the need arose for research in the area of using performance tests to evaluate the job proficiency of electronic technicians. The EPMS career management system evolved concurrently with an emphasis on performance-oriented training and evaluation. Also career progression and retention criteria were being changed so as to emphasize the demonstration of job skills.

It was anticipated that eventually the Army would design an Enlisted Career Management System for controlling career progression from the lowest through the highest skill levels which would be based, in part, on objective and standardized performance tests. There was, thus, a need for research which would examine methods of developing performance-based tests for such high skill MOSs in support of the new EPMS concept.

Classification. Upon entering the Army, personnel are given a series of classification tests that measure aptitude for training in the different occupational areas. This testing provides a basis for assigning an individual a military occupational specialty (MOS). With training and job experience, individuals develop and maintain qualifications for an MOS. Factors considered in the classification of individuals take into account both the individual's and the Army's needs. Factors such as the Army's need for personnel, MOS and grade imbalances, budget restrictions, physical status, training and experience, education, test scores, individual preference and hobbies may be considered in making an MOS assignment.

Within an MOS, an individual is classified by skill level. Currently, five skill levels are authorized: Skill Level 1 - Apprentice; Skill Level 2 - Journeyman; Skill Level 3 - Advanced Journeyman; and Skill Levels 4 and 5 - Leader and Supervisor Positions. Usually skill level correlates with pay grade. However, an individual may be awarded a skill level above his pay grade, but not below. This, in essence, indicates that an individual must be skill-qualified before he is awarded a promotion in pay grade. MOS and skill level qualifications are evaluated periodically using interviews, MOS evaluation tests, and performance appraisals and ratings. Decisions that can be made following these periodic evaluations are that the individual continue in his career progression, that he be reclassified to a lower skill level in the MOS, or reclassified to another MOS.

Utilization. It is the policy of the Army to obtain efficient utilization of enlisted personnel in accomplishing unit missions. However, if possible, this should be accomplished by placing personnel in positions which require their skills. The system also emphasizes that personnel utilization should provide for individual career progression. Policies have been established for the proper utilization of personnel, insuring that assignment will first be made to a duty position within the primary MOS at the appropriate skill level or higher. If this is not possible, the unit commander can assign an individual to primary MOS-related positions, or to secondary MOS positions. The policy does provide for authorized exceptions.

Development. Individual career programs require that personnel develop through both training and job experience. Each MOS is currently defined by a hierarchy of duty positions at the various skill levels. It is intended that periodic re-assignment be made following skill level qualification to insure that individuals get the comprehensive job experience needed for career development. The system assumes that skill level qualification is most often attained through training.

B. Research Problem

One underlying requirement for the three aspects of EPMS was periodic assessment of job proficiency for regulating the development and progression of individuals in a career program. Concern was expressed about how to validly evaluate skill proficiency especially for the higher skill occupational specialties such as electronic maintenance. Although performance tests had been developed by the Army technical schools to evaluate end-of-training proficiency, these tests primarily were concerned with the assessment of a technician's entry-level skills for those tasks involving the adjustment and repair of complex equipment. There was a scarcity of scientifically-based information concerning the gain (or loss) of these skills as a technician acquires job experience.

The use of tests that simulate some aspect of the real job situation, but still require the examinee to perform tasks or part tasks, has also been considered in evaluating skill proficiency. Such tests are called performance-oriented tests.

If performance-oriented tests were to be used, rather than actual job sample, hands-on-equipment tests, there was the question of how to validate such surrogate tests. That is, measurements of job performance of some kind would be required as criterion measures against

which the surrogate tests (performance-oriented tests) could be validated. *The primary problem for this research was then one of determining the feasibility of developing and using job sample, hands-on-equipment performance tests for measuring job proficiency in a complex, technical MOS.*

A secondary issue similar to the skill measurement inputs to the EPMS, was one of integrating skill acquisition in a career progression program. However, the exact locations where skills are actually acquired (and developed) were not known. *A second problem was, then, the identification of where electronic maintenance technicians acquired their skills.*

II. LITERATURE REVIEW - PERFORMANCE TESTING IN ELECTRONIC MAINTENANCE

It was assumed that technical changes in electronics, such as going from vacuum tube circuits to solid state circuits would influence performance evaluation approaches. Thus, the first effort in this research was to determine the state-of-the-art of applied performance testing in the electronic maintenance area. A literature review was conducted that covered over two hundred documents.

This review covers the use of job performance tests (PT) in electronic maintenance and was not intended to be exhaustive. A review covering the totality of the literature on applied performance testing was beyond the scope of this effort. The present effort was an attempt to locate only the literature that was directly related to electronic maintenance. Furthermore, the efforts cited can only be considered as representative of the work in the field. Many other relevant documents were reviewed but not reported here. It was felt that their citation would add only to the bulk of the review while adding little of a substantive nature.

A number of areas in performance test designing and application were considered. Separating PT development literature from application literature was difficult. In most cases, PTs were developed as criterion measures to be applied in evaluating training programs for entry-level skills. In this sense, the state-of-the-art in PT design has not changed since PTs were first proposed for Army use during World War II. Significant advances have, however, been made in the area of job description approaches and task categorization methods which are critical in the selection of items for the tests.

As used here, a performance test refers to a test situation that requires the behaviors necessary to perform job tasks under most of the

significant conditions that exist in the actual job. Another acceptable descriptive term for PTs is job sample tests, if they require whole task performance, use actual equipment, tools and materials found on the job, and are set under standardized conditions similar to job conditions. Tests that call for responses that are merely correlated with job behaviors or do not actually occur on the job are not included as PTs. Unfortunately, this description eliminates a majority of the literature from consideration as full-scale PT literature. Much of this associated literature was also reviewed and when appropriate is included in this summary.

This review is divided into sections that describe significant development and application variables. First, there is a review of the general PT development history within the armed forces of the United States. Next, test construction factors are covered. The third section deals with validity and reliability, a fourth section presents a survey of test usage.

A. Historical Perspective[1/]

Historically, performance tests as used in the world of work were found in the form of trade or task tests. At the present time, PTs have been used for at least the following six purposes:

1. As criteria for validating selection devices;
2. As criteria for skill certification;
3. For diagnosing performance deficiencies;
4. As instructional aids in training;
5. As criteria for various kinds of comparisons; and
6. As a predictive instrument in selection and job assignment.

During World War I, the Army used some trade tests for selection or assignment to jobs. During World War II, PTs were introduced as a means of improving and evaluating training in the routine maintenance, repair, and operation of equipment. During the early years of World War II, the need for electronic technicians in the military services mushroomed at an unprecedented rate. Radio communications requirements expanded rapidly, but the newly developed radar was also an

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1/ This brief historical review is based on information in Foley (1), Jenson (2), and the author's knowledge derived while working in military settings.

important factor in expansion. Each of the military services developed extensive programs for training electronic technicians. Most of these programs had a "job application" phase near the end of the course. Laboratory type performance evaluations on actual equipment were used extensively for both diagnosing student deficiencies and for formal evaluations.

Since World War II, performance test tasks, in the form of practical exercises, have been relatively widespread in application at training institutions. However, multiple task performance tests have been used only sparingly for economic reasons. For example, PTs must be given on an individual basis; they usually take longer to administer than written tests; they require an evaluator to be constantly present when process is evaluated, and they tie up equipment, tools, and materials.

In a somewhat different vein, the Army became interested in using PTs as criteria against which to validate selection instruments as early as 1948. About the same time, the Office of Field Forces, US Army, requested that the use of PTs be examined as means of evaluating job performance. This interest in job proficiency measurement was continued in 1965 when the Brown Board was set up to determine the job proficiency level of Army organizational maintenance personnel. Within the Air Defense Branch a diagnostic performance test was used to evaluate the proficiency level of Hawk CW Radar technicians.

During the '50s and early '60s, HumRRO conducted considerable research in the area of performance testing for evaluating maintenance training in electronics as well as other areas. The majority of the tests were developed, however, to evaluate the outcome of experimental training programs, and saw little use in the field. A brief description of these tests and their uses along with others is presented in a later section.

Following the decade of the '60s, interest in electronics maintenance research subsided. As a result, PT research in electronics was reduced correspondingly. However, the military services have maintained their overall interest in performance testing. In fact, the Army currently has placed a high priority on performance-oriented training as well as performance testing. In Work Unit ATC-PERFORM, HumRRO scientists have introduced performance-oriented training into a wide variety of MOS training programs. The performance tests are typically of a GO/NO-GO variety. That is, the student must successfully complete each test in order to progress. If he fails to reach criterion performance on a single test, he receives additional training and then is administered another comparable performance test.

B. Performance Test Construction

Standardization of conditions. In April of 1972, CONARC Reg 350-100-1 was published as a basic reference and guide for developing job description materials. A product of a job description essential for developing training and testing programs is the performance objective. There are three parts to the performance objective; a statement of the task to be performed, the standards of performance and the conditions under which the task must be performed. One important issue in the research on performance tests has been the standardization of conditions. Once representative job tasks are identified and test items selected, standardized test conditions must be established. This requirement has recently been viewed as troubleshome in the sense that variations in on-the-job performance were due to complex stimulus-response interactions. Asher and Sciarrino (*3*), Crumrine, et al. (*4*), Cory (*5*), and DiMarco and Norton (*6*), point out that any evaluation of job performance must take into account the interactions of individual and situational determinants of behavior. The implications for performance testing are that limiting the test situation by standardizing conditions will also limit the generalizability of the test results to total job performance.

In cases where conditions in the job environment are extreme, such as battle conditions, medical emergencies, extraordinary weather, etc., standard job conditions may be difficult if not impossible to duplicate. Osborn (*7*) suggested that techniques other than real world, hands-on performance testing will have to be used to evaluate job performance in such cases. He describes a continuum of fidelity of conditions varying from real world to the objective paper-and-pencil test. It is when duplicating job conditions is not feasible that the concept of simulation becomes important (*8*). The issue of standardizing test conditions was important for this research because of the possibility of the same performance tests being given at a number of locations as part of the same performance evaluation program.

Setting performance standards. The issue of establishing standards has received considerable attention in the literature. Along with the problem of setting performance standards, the question of how and what to measure also arises. The basic element underlying these issues is the question of what is to be done with the test results. Typically, performance data is used for the following purposes:

1. Describing job proficiency;
2. Determining promotion qualification;
3. Determining school or job qualification;
4. Obtaining diagnostic data--what more needs to be learned by an individual;
5. Determining retainability in a duty position;
6. For redesign of training program;
7. For equipment and tool design and redesign; and
8. For establishing human performance reliability for input to systems reliability estimates.

Providing data for these kinds of uses requires that scoring procedures be used that evaluate both the products of job performance and the processes of producing the product. Both scoring approaches were used in this research. Some examples of product measurement will be presented first.

Williams and Whitmore (*9*) evaluated electronic maintenance performance by measuring how long it took to get the radar back in operation and found a difference between new school graduates and experienced technicians. This criterion has been used in the past by the Army in establishing operational status of electronic equipment. The measurement of time to accomplish a task has been a common performance measure. Many maintenance PTs developed by HumRRO had a maximum time limit for finishing a test item. This often was an administrative requirement due to limited amounts of time available for testing. Since time is a pragmatic issue, it plays a significant role in the decision of how complex a PT can be.

Another common product measurement used is quality of the product; for example, a soldering test where the quality of the joint is evaluated. An Air Force test developed by Matrix Corporation (*10*), provided pictures of acceptable and unacceptable solder joints to be used as guidelines by the evaluator. In the evaluation of the quality of maintenance performance, the easiest measurement question to answer is, "Does it work when the task has been completed." This becomes essentially a GO/NO-GO type test.

However, Highland (*11*) pointed out early that being proficient is not an all-or-none question. This is the basis of the process approach to the setting of performance standards. Schwarz (*12*) presented a list of task activities in terms of the type of performance involved, as a means of categorizing process standards:

1. Visual discrimination;
2. Auditory discrimination;
3. Manipulation;
4. Decision-making;
5. Symbolic data operation; and
6. Reporting.

This approach to establishing performance standards stems from behavioral descriptions of required job performances. These descriptions are usually provided by job supervisors and there is usually a different description for new inexperienced technicians than for experienced personnel. Steadman and Harrigan (*13*) reported that new Navy school graduates are not expected to meet minimal job performance requirements during the first six months on the job. Siegel and Fischl (*14*) and Rafacz and Foley (*15*) also used multiple groupings of task behaviors. They used eight different performance descriptions (listed below) to define levels of electronics proficiency.

Level	Description
8 (highest)	Capable of Employing Electronic Principles in Maintenance of Equipment
7	Capable of Troubleshooting/Isolating Malfunctions
6	Capable of Calibrating Equipment
5	Knowing Relationship of Equipment to Other Related Equipment
4	Capable of Following Block Diagrams
3	Capable of Removing Equipment
2	Capable of Replacing Equipment
1 (lowest)	Capable of Employing Safety Precautions

When behavioral descriptions of jobs have been drawn up and the specific job activities identified, checklists can be prepared and used to evaluate the process aspects of job performance (*11*). Again, two approaches to evaluation can be followed at this level of job performance detail--checking whether the activity was performance (GO/NO-GO) or indicating on a scale how well it was done (quality).

Another approach to process measurement has been to record and classify the errors made during performance. McCalpin (*16*) indicated that one requirement for establishing a human performance reliability program was the development of a classification schema for errors. This approach would diagnose what kinds and with what frequency errors were being committed. A less complex error measurement approach is to indicate the sequence in which a list of job activities are performed.

In establishing performance standards, information such as that coming from work by Lintz, Loy, and Brock (*17*) must be considered. They found that 75-86 percent of the variance between performance times for electronic maintenance tasks could be accounted for by as few as two or as many as eight predictor variables, such as number of checks to be made, accessibility of components, and the level to which testing is carried (subsystem module or component). This type of information was used in this research to set a realistic time limit for finishing the specific test items.

C. Validity and Reliability of Performance Tests*

Validity. The tests developed in this research were designed as criterion referenced tests. Two viewpoints regarding criterion referenced test validation are frequently expressed in the literature. These viewpoints concern the validation operations to be followed.

The first viewpoint stems from a concern that performance tests used as criterion-referenced measures must be content valid. The individual's score must provide unambiguous information about his performance. To provide this information, the test must be constructed in such a way as to allow generalization to the domain, or universe, of job behaviors. Proponents of this view include Glaser and Nitko (*21*) and Popham and Husek (*22*).

The second viewpoint arises from the use of PTs as mastery tests. For those who take this stand, the ultimate validity question for criterion-referenced tests concerns the accuracy with which the test classifies individuals into mastery and nonmastery categories. This approach is based upon empirical discrimination assessed against an appropriate external criterion. Proponents of this predictive validity approach include Hambleton, Novick, and various associates (*23, 24*).

*A significant input to this section was provided by Dr. C. Kneer of the Army Research Institute, through personal correspondence.

The complex interaction of these approaches is exemplified by the following points: (a) content validity is often compromised in performance testing because of pragmatic constraints; (b) therefore, empirical discriminant validation is required to augment assertions of content validity; (c) caution must be exercised in empirical validation operations to prevent further compromise of content validity. In brief, content validity is necessary but not sufficient evidence of performance test validity. This merging of the viewpoints is best exemplified by Harris (*25*). This view of merging content and empirical validation was favored in this research. These concepts, the methods for achieving content validity, and for evaluating empirical validity are expanded in the following paragraphs.

Item selection. The basic assumption underlining the construction of pure performance tests is that the test resembles the job situation as closely as possible. It follows then that PTs should be content valid. The essential issue becomes one of selecting test items that accurately represent job tasks (*26; 27*). Williams and Whitmore (*28*) stressed that "performance tests must be rigorously derived from job tasks and that those job activities sampled must be representative of the entire job in order to maximize test validity. However, since pragmatic considerations dictate the sampling of job tasks, they suggested that those representative tasks for maintenance jobs be selected as a function of equipment malfunction frequency data. Vineberg (*29*), Shriver (*30*), and Highland (*11*), among others, have also proposed using malfunction data for task selection.

The author is not aware of literature that discusses the concept of task criticality as a factor influencing validity. But this concept is receiving increasing attention in task analyses efforts within the US Army. The concept is being used in the decision as to where various tasks should be trained. A problem has emerged in these efforts in that an acceptable operational definition of task criticality has not been agreed upon. An initial definition of criticality was used identifying tasks to be trained in the US Army's Training Extension Course (TEC). It is this definition that was used in this research to select test tasks. Four levels of criticality were defined as follows:

Value: 0 = Task is not relevant to the ability of a soldier to survive or to accomplish his individual duties as a member of a combat arms unit. This is a task which is never performed or only under very remote circumstances.

Value: 1 = Task is relevant to survival or accomplishment of individual duties but is relatively unimportant ("nice-to-know"). This implies the ability to perform a task which could be useful but not essential.

Value: 2 = Task is relevant to survival or accomplishment of individual duties and is considered important but not critical to adequate performance. This implies the ability to perform a task that would definitely enhance under reasonable circumstances the individual's survivability or the accomplishment of his mission.

Value: 3 = Task is critical to survival or accomplishment of individual duties as a member of a combat arms unit. This implies the ability to perform a task that is crucial to survival under reasonable circumstances or to adequate accomplishment of individual mission.

Vineberg (*29*) has proposed to study the use of specific behaviors to represent a general class of job behavior. Mecham and McCormick (*31*) reported a similar approach in research using the Position Analysis Questionnaire (PAQ). They identified nearly 200 job "elements" in analyzing specific jobs. Elements consisted of items such as "sound pattern discrimination" and "use of precision tools." They felt that some combination of these elements could be employed to describe the great majority of technical jobs. Presumably, in employing this type of approach, performance test items would be based on the elements which defined the particular task performance being evaluated. Vineberg and Taylor (*32*) have proposed an approach to the sampling of tasks for PTs so that the various dimensions of job behavior are represented. In selecting dimensions for sampling, they felt that functional aspects of job performance and task difficulty are to be preferred in that they are perhaps more closely related to the underlying demands of jobs. Relative occurrence of tasks and the criticality of tasks, while having some impact upon performance, reflect system requirements more closely than the underlying behavioral requirements.

Other researchers have also developed PTs from behavioral descriptions of jobs. Pieper, Folley, and Valverde (*33*) developed a job PT for Air Force Weapon Control System Mechanic based on tasks derived from detailed behavioral descriptions of the job. Specific items selected for the test represented three major groups of job behaviors: Operational Checkout; Troubleshooting; and Auxillary Task Performance. Glaser and Nitko (*21*) indicated that representative samples of tasks from defined "domains" should make up the tests. Whitlock (*34*) proposed a technique similar to Flanagan's (*35*) critical incident technique for identifying essential job behaviors or "specimens." He defined a performance specimen as "an incident of relevant performance which is uncommonly effective or uncommonly ineffective." In research for the Navy, Rigney, Fromer, Langston, and Macaruso (*36*) identified

criterion behaviors that represented the terminal behaviors for a maintenance course and these were also used as PT test items. This approach has been also used in Army and Air Force schools.

In practice, it is not really possible to separate the standardization of conditions from item selection, as the conditions are a part of the job. This has been viewed as a Task Taxonomy problem by several researchers (*37; 38; 39; 40; 12; 41*). In general, they concluded that task classification must be relevant to the purpose of the performance test. That is, if certain conditions are always a part of the task, then they must be specified in the item. Therefore, the purpose of the test must be clearly stated. For example, if the purpose is simply to assess the ability to use test equipment, one set of conditions might be employed. If the purpose is to assess ability to employ test equipment in cramped quarters, on a ship in high seas, a different set of conditions would probably be necessary.

Another technique for test item selection that is receiving research attention is multidimensional scaling (MDS). Schultz and Siegel (*42*) used MDS analysis to identify four factors representative of job tasks of aviation electronics technicians. Siegel, Pfieffer, and Schultz (*43*) conducted further research using MDS analysis for the Navy. They found that different populations perceived the job domains of the aviation electronics technician similarly. One research problem in using MDS is the large number of responses individuals are required to make on the questionnaire. Rigney (*44*) also used MDS to develop job tasks for PT for electronic maintenance by identifying significant psychological variables. MDS was not used in this research because of the requirement to develop hands-on equipment, job sample tests. However, in the development of surrogate tests, MDS would be a useful technique.

Job analysis. Prior to data gathering, the primary consideration in criterion-referenced test development is content validity. Various sets of guidelines are available which, if followed, help to assure content validity of a test of a set of instructional objectives. The essential point is that the measurement must provide unambiguous information about his performance. For item generation and task sampling in complex job performance contexts, the job analysis approach has proved fruitful (*45*). Procedures based on the job analysis were followed in this research with some modification.

The task analysis separates the complex job behaviors into manageable components that are to be tested. Task analysis precedes the test construction to provide a logical basis for the content domain definitions. Army task analysis produces task lists from which

performance objectives are written. The performance objectives, in turn, contain specific behavioral steps, conditions, and standards on which test items are based. The performance objectives establish the domain by specifying the content. The standards and conditions guide boundary specifications regarding testing situations, response alternatives, and standards of correctness.

Once the domain is specified and the performance objectives are in hand, items are written for the test. Hambleton, et al. (*24*) advocate both judgmental and empirical analysis, based upon their assertion that "Because the domain specification is never completely precise, we must determine the quality of the items in a context independent from the process by which the items are generated". (p. 17) They present methods for analyzing ratings of item relevance by content specialists.

Reliability. PT reliability has received more attention than validity previously because of attempts to apply traidional reliability concepts to PTs.

Several reliability coefficients for criterion-referenced testing (CRT) have been proposed. One of the prime concerns of CRT reliability is the consistency of classification, in situations where individuals are classified into two or more mutually exclusive categories. An example is CRT after instruction to determine whether or not students have mastered the instructional objectives. Individuals are classified as masters if they achieve a score equal to or greater than a given cut score and nonmasters if they fail to achieve the cut score. Consistency over time, analogous to test-retest reliability, refers to similarity of classifications of individuals over subdivisions of the test (e.g., split halves, subtests, or items). When the CR tests are hands-on performance tests, judgment of the individual's behavior by a rater contributes to unreliability. Error may occur in the rater's observation and scoring. Interrater and intrarater consistency estimates have been applied to CR performance tests.

One school of CR measurement advocates methods differing in detail as to whether classification consistency is determined over multiple forms, comparable samples, or repeated administrations, but similar in use of a 2x2 framework (Figure 1) where I and II represent two administrations, test halves, items or other measurement forms (*46*). N is the total number of individuals and a, b, c, and d represent the number of individuals classified into that cell. For example, if I

		II		
		Master	Non-Master	Marginal Frequency
	Master	a	b	a+b
I	Non-Master	c	d	c+d
	Marginal Frequency	a+c	b+d	N

Figure 1. Fourfold Table Format

and II represent two administrations of the test, then a equals the number of individuals who are classified as masters both times, b equals the number of individuals who are classified as masters based on their scores the first time but nonmasters the second time, c equals the number of individuals who are classified as nonmasters the first time and masters the second time, and d equals the number of individuals who are classified as nonmasters on both administrations.

Conceptually, consistency or agreement is measurable as the proportion of individuals consistently categorized. In the format just presented, a and d are the numbers of individuals consistently classified out of the total N individuals. Thus, a measure of reliability advocated by Carver (*46*) and Crehan (*47*) is the index of agreement

$$\text{reliability} = (a+d)/N$$

However, as Hambleton, Algina, and Coulson (*24*) and Swaminathan, Hambleton, and Algina (*48*) pointed out, this index of agreement does not account for the extent of agreement expected by chance. They advocate coefficient Kappa (*49; 50*) in which the joint and the marginal proportions are used to correct for chance agreements. The upper limit for Kappa, +1, is reached only when the marginal proportions for the repeated administrations are equal. If any individual is classified differently on the repeated administrations, Kappa is less than +1 (*51*).

Analysis of the fourfold table can be accomplished by a variety of measures of association such as the Phi (ϕ) coefficient or the tetrachoric correlation. The usefulness of Phi is limited by the effects of test difficulty on the magnitude of the coefficient. By test difficulty is meant the proportions of individuals who are classified as masters in situations I and II. When the Marginal distributions are asymmetrical, Phi does not range between +1 and -1. The extent of distortion and obscured interpretation have led some writers

to recommend against Phi (*52*), while others advocate its use (*53*). The tetrachoric correlation is not ordinarily affected by difficulty level, but has other disadvantages (*52*). Use of the tetrachoric correlation assumes a bivariate normal distribution and computation is prohibitive without computing aids.

Swezey, et al. (*53*) presented an excellent discussion of reliability research for CR tests. CR measurement advocates frequently claim that variance dependent statistics are inapplicable in CR testing because CR test scores have restricted variance (*22*). However, approaches are available to overcome this objection and as a result, NR techniques have been demonstrated by some to be effective in CR measurement (*54; 55; 56; 47*).

Previous literature on hands-on performance testing reports reliability estimation using NR techniques. Schmidt, et al. (*57*) found that of the performance testing reports dealing with reliability, most were devoted to interjudge reliability (e.g., *58; 59; 60; 61*). Some reports focused on intrajudge consistency (*62; 63*). Despite the fact that stability over time is a prerequisite for the utility of a performance test, Schmidt, et al. (*57*) found only one report of test-retest reliability (*64*). Internal consistency estimates were reported in three cases (*58; 65; 66*).

The lowest reliability estimates in the review by Schmidt, et al. (*57*) were obtained in internal consistency analyses. The low internal consistency values indicate that the tests are made up of rather unrelated components. For example, Bornstein, et al. (*64*) reported an internal consistency coefficient of .61 for a test composed of 13 separate military performance tests. The tests covered hand grenades, first aid, signal communications, map reading, and a variety of other military skills. The low internal consistency coefficient verifies the diversity of the test content.

In general, if multiple test items measure the same objective, then high internal consistency within the objective is desirable. In that case, the conceptual homogeneity and response homogeneity are congruent (*25*). In contrast, response homogeneity is not expected across tests that measure different objectives. As Schmidt, et al. (*57*) point out, if traditional homogeneity is enhanced within objectives, but homogeneity is decreased across objectives, then both reliability and validity can be increased. Since jobs tend to be multidimensional, multidimensional performance tests are more likely to be valid than unidimensional tests for measuring proficiency.

The tasks identified in this research that make up the pool from which test items could be selected, were quite heterogeneous in content.

The performance tests were also designed to be criterion referenced. Based upon the above discussion, coefficient Kappa was selected as one means of evaluating test reliability. In order to evaluate the scoring consistency, interrater reliability was also evaluated.

D. Survey of Test Usage

The state-of-the-art in performance testing has been reviewed periodically (*67; 26; 68; 69*). The consensus has been that PTs have not been widely used, primarily due to the heavy requirements for personnel and equipment resources. Nevertheless, considerable effort has been expended on the development of PTs for use in electronic maintenance training research, and some discussion of the various approaches seems to be called for in this review. Most of the tests were developed from job description information and were assumed to be content valid. Reliability of the test measurement was assessed in several cases, but others did not mention test reliability. Test difficulty was seldom considered and then only relatively gross statements were made.

Rulon, et al. (*70*) were among the first researchers to construct a troubleshooting test for evaluating maintenance proficiency. A test for Q-24 Radar Mechanics was developed using actual operating equipment. It was in this research that the TAB test was developed for group testing the "process of diagnosing malfunctions" of electronics technicians. However, the TAB test was found to have no more predictive validity than other paper-and-pencil tests.

One of the earliest PTs to be used by the Army in evaluating electronic maintenance job performance was developed by Baldwin, et al. (*71*). Using malfunction data derived from job task survey, they constructed a three-hour test for measuring job effectiveness of radar mechanics. Performance data was obtained on ability to keep equipment at an operational level and on returning malfunctioning equipment to the operational level. The test used actual operating equipment.

The split half and inter-rater reliability coefficients for this test were high. They also found that the test was more difficult for inexperienced personnel than for experienced. This test was concluded to be a satisfactory criterion instrument and was used in several HumRRO research projects to develop and evaluate training procedures.

Williams and Whitmore (*9*) under HumRRO Work Unit ACHILLES also used an analysis of malfunction data to develop a PT for measuring

job performance of NIKE AJAX IFC maintenance technicians. The PT included 27 items and required 7 hours to complete. The test covered three major areas: troubleshooting, adjustments and replacement of a soldered-in component. Four subsystems were used as test vehicles--the acquisition system, the computer system, the target tracking system, and the missile tracking system. The split-half reliability for this test was .876. In addition, a written test, measuring retention of knowledges required in school was employed. Two shorter versions of the PT were also constructed. Each included five troubleshooting and four adjustment items, requiring two and a half hours to administer.

In 1956 HumRRO researchers began work under work unit REPAIR in which field data was obtained on actual job performance of radio repairmen. The data were used in identifying elements of the repairman's job and for developing a field-oriented proficiency test. Brown (*72*) described the Repair Proficiency Test Battery developed to evaluate training program effectiveness. The test included four parts: troubleshooting, test equipment use, repair skills and achievement. The reliability coefficient for the test was .60. It was in this effort that the terms "functional context" training was coined by Shoemaker (*73*).

The Navy had identified various kinds of performance evaluation approaches which were looked at by Harris and Mackie in 1962 (*74*). Specifically they studied the extent of use of practical performance testing in the Navy. They found only limited usage of PTs aboard ship (12 of 204 cases). Performance ratings by supervisors were used instead. On the other hand, at Navy Schools, PTs were used extensively. Twenty eight of 36 schools used one or more PTs. It was reported by ship-board personnel that PTs were infeasible to be used. They took too much personnel and too much equipment time. They also felt that it was "burdensome to administer properly" and too difficult to set up realistic conditions. Also, special non-available equipment was required and there was a possibility of damage to operational equipment used in the tests. Lastly, it was felt that it was extremely difficult to set objective performance standards.

Shriver (*30*) reports a PT that was developed from problems identified as commonly occuring during the first 8-12 months of job experience of radar repairman. The test was developed as a means of identifying the skills and knowledges needed to operate and repair electronic systems. Administration of the test required nine days. The test included items on energizing, adjustment, troubleshooting, and using common and special test equipment. Validity of the test was presented logically rather than statistically. The Spearman-Brown reliability coefficient was .70.

In 1964, Shriver, Fink and Trexler (*75*) modified the M-38 repairman PT to be used in measuring troubleshooting performance in the M-33 tracking subsystem; the shorter test consisted of 1/3 of the system test.

McKnight and Butler (*76*) developed a PT used for evaluating electronic maintenance performance following completion of an experimental ordnance radar repair course. A total of 92 items were selected on the basis of frequency of task performance and expected variability in performance. It required from 20 minutes to 10 hours to complete the items, with 11 days needed to finish the entire test. The primary measure of proficiency was the speed with which tasks were accurately and safely completed.

Rigney, et al. (*36*) used a symptom-malfunction matrix completion test for evaluating performance on a blocking oscillator. The test involved six troubleshooting problems in which voltage and resistance readings and the number of components replaced were used as performance measures. They found that technician troubleshooting procedures did not conform to a Bayesian model criterion and, in fact, they were only about one-third as efficient as the Bayesian model performance. A Bayesian troubleshooting model would indicate for any given procedure that has been performed the subsequent sequence of troubleshooting steps with the highest probability of identifying a specific malfunction.

The BEAT (Basic Electronic Assembly Test) was used by Steinemann (*77*) as a test of practical performance abilities. The test had face validity and the time-to-complete score was found to be predictive of training achievement. A record of errors committed was useful for diagnosing performance difficulty, but was not useful for predicting job performance.

The majority of PTs described so far relied primarily on malfunction data as criteria for selecting test items. Pieper, Folley and Valverde (*33*) used behavioral descriptions of job tasks to construct a PT for the Air Force's Weapon Control System Mechanic/Technician. The test had three parts: operational checkout, troubleshooting, and auxillary task performance. The test used the F-IIIA Simulated Main Task Environment. A profile of scores for job elements was obtained, without a single overall test score. They concluded that "the test appears to be reliable, valid, economical, and easy to administer".

Gebhard (*78*) describes a PT used for the electronic communication equipment maintenance technician that was scored on a GO/NO-GO basis. It consisted of 18 malfunctions to troubleshoot, plus alignment,

removal and replacement of components, location and identification of parts, and overall operational checks. Administration of the test required 6 days (22 hours).

Steadman and Harrigan (*13*) used a series of PTs that were job task representative, but not job sample hands-on-equipment tests. In an effort to evaluate the Navy's Selected Electronics Training (SET) program, they tested Data System Technicians that had graduated from the program. There were four PTs. A troubleshooting test was used that was quite thorough in terms of the kinds of job tasks required. The technician had to perform corrective maintenance procedures to diagnose and locate malfunctioning parts. They were measured on their successful completion of 18 troubleshooting steps, the selection and use of test equipment, interpretation of manuals and schematics, and the observation of safety procedures. The other tests were a test equipment test, a cable check test, and a soldering test. Subjects had to demonstrate the use of three pieces of test equipment and were scored on each measurement check and/or essential procedure. In the cable test, they had to check the condition of ten conductors and identify the shorts and opens. In the soldering test, they had to replace four soldered-in components and were scored on procedural steps and on the quality of the finished joint.

A significant difference between these earlier PTs and the ones developed in this research is that the ASSALT tests are for a different generation of electronic equipment. Today's radars use solid state components and integrated circuits vs. the vacuum tube circuits of yesterday. This difference was believed to be significant in terms of testing time that would be required and also possibly in terms of establishing test reliability.

Literature Review Summary

The literature has revealed a move in performance evaluation from the use of norm referenced tests to criterion referenced tests. This has presented a problem as to the approaches to be used in evaluating the validity and reliability of performance tests. For this research, a merging of two approaches for determining test validity were used. First, a procedure was adopted for the selection of test tasks to maximize content validity. However, a primary constraint, testing time, caused two general types of job tasks to be excluded from the test task pool. All items that for mechanical or procedural reasons required extended time for their performance were eliminated. Other tasks that because of their complexity required a long time to complete were also eliminated. As indicated in the literature review, such pragmatic limitations may compromise the content validity of a test.

The second approach used the mastery classification approach. Three criteria measures were selected that have been used frequently in previous performance test research. Amount of job experience, supervisor rating of job performance and MOS test score were the three independent variables used to define masters and non-masters.

There are several factors that could interact with job experience to reduce the relationship between test performance and experience. If new operational and/or test equipment or new procedures have been adopted and are included in the tests with which the experienced technician is not familiar, his test performance may be degraded. Also, if the experienced technician has been misassigned to extra-MOS duties or promoted out of a technician duty position, his job experience may not truely reflect his technical experience. Data was obtained to evaluate the influence of these factors in this research.

Supervisor ratings were used because it was assumed that the supervisor would have knowledge of such performance measures as whether or not the equipment which a technician has repaired works; the amount of time required by the technician to repair a malfunction relative to other technicians; and the number of items of equipment upon which a technician worked that were returned because of faulty repair.

MOS test scores were used because some job knowledge is necessary for adequate electronic maintenance performance.

The literature indicated the importance of standardizing conditions for testing to maximize test validity and reliability. Care was taken, therefore, to identify the critical conditions required to support the functions required in job tasks. This was also necessary in order to maximize interrater agreement in scoring. This was an issue, because testing at different sites was required.

The literature review indicated that two approaches could be used to test scoring--measuring product or process. The decision of which approach to use is a function of the use to which the test results are to be put. This research did not presuppose to what use such PTs would be put and thus both scoring approaches were used. The reliability of the product approach was evaluated using the Kappa coefficient and the process approach reliability was determined using an interrater reliability coefficient.

The discussion of previous performance test usage revealed several additional considerations that should be made in adopting a test scoring approach. These concern the criteria to be selected for evaluation. Four dependent variables emerge as descriptive of proficient

job performance. These are: (1) time of performance; (2) correct performance of job tasks; (3) correct use of tools and test equipment; and (4) use of safe operating procedures. All four of these variables were adopted for evaluating job proficiency.

Research Approach

There had been a considerable amount of research conducted on the development and use of performance tests prior to this research. It was necessary to identify variables that might be important in the development of performance tests for evaluating job proficiency of high level skill MOS. The first task undertaken was thus a review of the literature in electronic maintenance performance evaluation.

Once the vehicle MOS was selected, the job tasks were categorized in order to provide an approach for selecting tasks for inclusion in the performance tests used in the research. It was not intended that the entire MOS be represented in this categorization. Tasks were to be clustered on the basis of relevant dimensions. This research task included a review of MOS materials and interviews with experienced personnel. The experienced technicians were also asked to rate the criticality of frequently performed tasks.

The second research task included the development of prototype performance tests for the 26C20 MOS. Tests were not developed for each category of job tasks. The tests were developed as hands-on-equipment work sample tests. Test administration and test scoring procedures were developed in some detail. The evaluation of the performance test included obtaining validity and reliability measures. Two scoring approaches were taken (product and process measures) for three performance variables--correct task performance, safe operating procedures and proper use of tools and equipment.

The prototype performance tests were administered to a total of 43 electronic technicians spread over four Army posts. A total of seven evaluators were used, but only one evaluated all 43 subjects.

The third task was the collection of information used to describe where technicians acquire their skills. An attempt was made to identify where specific skills were acquired, but considerable disagreement was found on the fragmentation of the term skilled technician into specific skill elements, and also as to the meaningfulness of such a breakdown.

III. CATEGORIZATION OF SKILL ACTIVITIES

A. Selection of MOS

The objective of this task was to select a complex technical job as a research vehicle. The MOS to be used had to meet several criteria:

1. It had to have a spread of low to high skill proficiency.
2. It had to be in a career field that was not becoming obsolete.
3. It had to be an MOS where military support could be obtained.

It had been proposed to select a MOS from the electronic maintenance field, since HumRRO's experience has shown that technicians gain in skill proficiency with job experience. Steadman and Harrigan (*13*) had also indicated that graduates of Navy electronic maintenance schools were not expected to meet even minimal job performance requirements for the first six months on the job. An MOS with sufficient personnel for testing purposes that met the criteria was 26C20, Ground Surveillance Radar Repairman. Technicians holding this MOS are responsible for the maintenance and repair for three radars. Upon completion of an additional school course, technicians are also responsible for the Forward Area Alerting Radar (FAAR). The technicians are trained to perform maintenance at the organizational, direct and general support levels. A complete description of the duties of MOS 26C is included as Appendix A.

B. Review of MOD-B Report

As part of the effort leading to the categorization of job skills for the 26C technician, data and information were obtained from two sources in addition to the Technical Manuals. First, a copy of the Military Occupation Data Bank (MOD-B) report for February-May 1973 for the 26C MOS was reviewed. This led to the development of a job rating form. The second source was experienced technicians who were individually interviewed.

A MOD-B report presents a compilation of responses to a questionnaire about the job tasks and conditions for an MOS. The purpose of the questionnaire is to obtain information to be used for:

1. Describing the duty MOS based upon what is actually done.
2. Determining what changes may be necessary in the MOS.
3. Insuring that duty positions are properly graded.
4. Improving service school training.
5. Improving MOS tests so as to reflect what is actually done on the job.

The data of specific concern in the review of the report were the responses to the job task questions. To each question the individual must provide two responses--whether or not he performs the task, and if he does, how often (seldom, occasionally, frequently).

A total of 329 tasks were listed in the MOD-B report: one hundred and thirty tasks were reported as being performed by 50% or more of the responding technicians. These were used in a job rating form (see Appendix B) subsequently filled out by experienced technicians during an interview. A breakout of a gross categorization of tasks is presented in Table 1.

TABLE 1
GROSS CATEGORIZATION OF TASKS FOR MOS 26C

Task Category	# of Tasks in MOD-B Report	# Tasks Performed by 50% or more
Prepare paperwork	34	10
Use written material	14	6
Use basic electronics	61	19
Equipment related	220	95

C. Interviews With Experienced Personnel

In the evaluation of job performance it is important that critical tasks be included in the evaluative process. Interviews were conducted with 13 experienced individuals familiar with the duties of 26C technicians. A structured interview was used (see Appendix B). Each individual also was to rate the criticality of the tasks identified in the review of the MOD-B report.

Tasks identified as critical by most of the interviewees were:

a. Determines current by calculation.
b. Analyzes schematic diagrams.
c. Uses schematic diagrams in isolating faults.
d. Uses proper soldering techniques.
e. Repairs IF preamplifier.
f. Tests for shorts and opens.
g. Aligns:
    1) Receivers;
    2) Transmitters;
    3) Indicators;
    4) Synchronizers;
    5) Synchronizer circuits;
    6) Synchronizer systems;
    7) Power supplies;
    8) AGC circuits;
    9) Video circuits;
    10) Range market circuits;
    11) IF preamplifiers;
    12) Audio circuits.

The interviewees were also asked to describe the job of the 26C in terms of main work categories, and the following list was provided:

a. Inspect.
b. Troubleshoot--determines-localizes problems.
c. Test for troubles.
d. Analyze.
e. Repair and maintain.
f. Align.
g. Replace.
h. Identifies what cannot be done by 26C.
i. Overall performance testing.
j. Performs modification work orders.
k. Uses forms--records.

They also reported that when assigned to 26C duty position, the technician spends about 90 percent of his time on MOS duties. However, as this research progressed to the field evaluation stage, it was found that a majority of 26C technicians were not actually assigned to MOS duty positions.

The results of criticality ratings by the interviewees are summarized in Table 2.

TABLE 2

FREQUENCY OF TASK RATINGS BY CRITICALITY LEVEL

	Criticality Level of Task			
	0	1	2	3
# of tasks where 50% or more used the rating	0	3	45	85

As can be seen, the experienced technicians generally agreed that a majority of the tasks that are performed by 50 percent or more of the 26Cs are important or critical to adequate job performance.

Information was also obtained on the commonly occurring malfunctions. This information was asked for to help identify problems that would be realistic for evaluating job performance. Malfunctions were identified for each of three radars. The most common malfunctions dealt with by the 26C on each of the three radars are:

a. AN/PPS-4A--transmitter system
range system
modulator
magnetron adjustment
power cables

b. AN/PPS-4-- control indicator
gears in antenna
receiver transmitter
2300 block--power supply

c. AN/TPS-33--power supply
control indicator
range indicator
ATC
frequency convertor-CU937
amplifier dector power supply-AM2575
resistor hooked to transformer in transmitter circuit
high level amplifier

Anticipating that testing time would be limited, malfunctions that would require an extensive amount of time were also identified. The malfunctions reported to be the most difficult to repair were:

a. AN/PPS-4A--transmitter--hard to get at
IF strip alignment--no set procedure for doing it
magnetron--power convertor

b. AN-PPS-5-- antenna positioning system
magnetron in Block 100
Block 100--difficult to get at

c. AN/TPS-33--CRT--difficult to get components out
indicator loop
mixer duplexer

Each technician was asked to describe his general troubleshooting procedures. Troubleshooting had been identified as taking up about 90 percent of the technician's time when working in an MOS duty position. The general trouble procedures reported were quite similar. Specific sequences for use of test equipment were not reported. Generally, the procedure was to turn on the equipment and make operational checks. This would provide general symptom information. Next, test equipment would be used to gather additional symptom information. Tests would continue until the problem was localized to a section. If possible, the specific problem within the defective section would be identified. The problem would then lead to repair or replacement of a component. If replaced, the defective component or section would be sent to higher maintenance.

When asked to describe a fair performance test, all respondents indicated that a troubleshooting problem would be the best. Most troubleshooting problems require the application of critical skills and would require as much use of test equipment and theory as possible. They also indicated that the problem should be one that most proficient maintenance personnel could complete in a specified time period. It was determined that most single malfunctions, excluding those identified as most difficult, could be identified in less than an hour. This would not include repair procedures.

D. Categorization of Tasks

The data and information described in the above sections were reviewed with the conclusion that the important and critical tasks could be categorized in a matrix similar to Table 3.

Table 3

TASK CATEGORIZATION MATRIX
FOR
MOS 26 C

JOB ACTIVITY CLUSTERS

Equipment System Component Clusters	Troubleshooting	Removal and Replacement	Bench Servicing	Adjusting and Alignment
Radar Set				
Transmitter				
RF				
Receiver				
Range Finding				
Target Indicator				
Antenna Positioning				
Power Supply				

At first, the concept of skill was considered as a means of categorizing the relevant job performance dimensions that differentiate between levels of proficiency. As it turned out, differences between proficient and non-proficient technicians was operationalized in terms of time to repair specific malfunctions. When a technician graduates from his maintenance course, he performs his job by the book, which takes time. He has little knowledge of various malfunctions that occur in the field. The kinds of malfunctions that are dealt with in school are those that are easiest to insert in the equipment. As he gains in experience, he deals with an increasing variety of malfunctions, learning the specific symptom information that is relevant to the problem. When he comes across a problem a second time, he will tend to go directly to the malfunction rather than using the book troubleshooting procedure taught in school. This takes much less time. His knowledge builds as he is required to perform certain kinds of related tasks on different parts of a radar system. Thus, the matrix in Table 3 represents a comprehensive summary of equipment-related categories of job tasks that reflects the need for equipment knowledge as well as the need for maintenance skills.

An attempt was made to sort tasks on an equipment-related and data-related basis, but this did not yield a categorization that was meaningful. Since troubleshooting makes up about 90% of the technicians job, he is continually seeking data and information from operational equipment through the use of testing equipment in a sequence of steps that are dictated by the information he obtains. Given one bit of symptom information, the step in the fault isolation process may be quite different than would be required if another bit of symptom information had been obtained. Another point here is that different technicians may make different but correct subsequent checks for additional symptom information. The inter-reliance of data, equipment, and technician experience is such that it did not make operational sense to separate task behaviors on this basis.

IV. SKILL ACQUISITION SOURCES

The EPMS includes an integration of training and work experience as a means for individuals to obtain requisite skill proficiency for adequate job performance. The Army utilizes a variety of training approaches. In addition, other training/education sources are available to personnel.

When this research was proposed, it was assumed that the acquisition of complex technical skills occurred at specific identifiable locations. As a means of identifying these sources, individuals were interviewed to determine where they developed their skill proficiency.

Initial interviews with experienced technicians indicated that electronic maintenance skill proficiency was developed primarily on the job. Initial exposure to electronic maintenance skills usually occurred in a training course of some kind such as: MOS school training, MOS short course training at the job location, other than primary MOS school training, civilian school (both before and during military service), and on-the-job training.

School training for the 26C MOS had been conducted at Fort Monmouth and Fort Huachuca, the new home of the USAICS. This course provides a basic introduction to electronic and radar theory. Once the individuals are familiar with the radar and test equipment, there is a heavy emphasis on developing troubleshooting skills. At Fort Huachuca, the Ground Surveillance Radar Maintenance School is not authorized to make equipment repairs. All maintenance is performed by a DS/GS shop on the base. As a result, troubleshooting training does not include repair. The trainees are required to troubleshoot the radar set or some system to successive levels of fault isolation (to system, subsystem or block, stage, and component). In the time allotted for training, the instructors feel that if the trainee can learn to successfully isolate to the block, they have been successful in their training efforts. Further isolation to stage and component becomes a matter of time. It was obvious that a new school graduate may have been introduced to a majority of the skills for job performance but that proficiency would have to be developed on the job.

This was apparently the case, since several supervisors of 26C personnel indicated that they would generally not allow a new school graduate to work on equipment alone for at least six months. It was felt that the man must become familiar with the equipment and practice basic skills for a minimum of six months in order to become competent.

This was not entirely the case with individuals who, upon finishing the 26C20 course, went directly into the FAAR maintenance course. The basic maintenance skills that were developed on-the-job in the first case were developed while attending the FAAR course by these individuals.

During FY 74-75, there was a restructuring of the 26C MOS. Before that time, the 26C20 MOS qualified the individual to perform organizational level maintenance only. Direct support and general support maintenance (DS/GS) was performed by 26C30 technicians. In FY 74 the radar operator (17K) course was modified to include training on organizational maintenance. The (DS/GS) MOS was changed from 26C30 to 26C20. Those individuals who had previously held the 26C20 MOS were offered the option of retaining that MOS or changing to 17K20, the operator MOS. Many elected to retain the maintenance MOS. They subsequently

were familiarized with the DS/GS maintenance tasks in one of two ways. They either were given on-the-job training or took a short course to upgrade their skills. This short course was given in some cases, at the job location and, in other cases, at Fort Huachuca.

The technicians who took part in this research were divided among the various training locations as follows: organizational maintenance training - 12; DS/GS maintenance training - 15; FAAR maintenance training at Fort Huachuca - 5; Fort Monmouth maintenance training - 6; and on-the-job training - 5. In addition, many individuals had taken other electronic courses of various kinds as a means of developing more knowledge and skills. There were also two individuals who had served previously in the US Marine Corps as electronic technicians. Others had held civilian jobs that required some knowledge of electronics.

On-the-job experiences varied widely among the sample of technicians used in this research. Many had very little actual experience on the maintenance of the radars on which they had received training. There were three reasons for this: in some cases, the equipment was not available; some technicians were not assigned to a 26C20 MOS duty position; and in other cases, only one or two technicians in a maintenance shop were actually used to repair the radars. In some maintenance shops, individual technicians specialize in the repair of a specific system such as the receiver system of the radar.

In summary, skills in electronic maintenance are developed variously at training and work locations. Technicians cannot readily identify where their skills were acquired, but generally agree that the skill requirements are introduced in some training program and then developed to a proficient level as a result of experience in the application of the skills.

V. DEVELOPMENT OF PERFORMANCE TESTS

A. Performance Objectives

Both product and process approaches to evaluating job performance were considered in this research. Therefore, it was necessary to develop complete performance objectives (PO) for important and critical tasks. Theoretically, the evaluation of job proficiency using performance tests could be based upon a random selection of job tasks to be included in the test. This would permit generalization of test performance to job performance. Performance objectives for MOS 26C are included as Appendix C. Each PO contains a statement of the task action, the job conditions under which the action is performed, and

the standard of performance. The standard includes a list of steps and procedures required to perform the action. This list would be used in a process evaluation approach.

B. Selection of Test Items

A significant problem existed in determining the "size" of the test that should be used in this research. The literature provided little guidance. Earlier PTs had used from three problems to 120. Testing time had varied from 1/2 day to 9 days. Since MOS evaluation was an important issue, the MOS testing system was reviewed. Most written MOS tests take three-four hours. Each has 120 items which yield a score of 160 points. This review also was of little help in that if tasks were to be used that required an hour to perform a maximum number of test problems that could be used would be four if the same amount of time were to be allowed.

Finally, an analysis of the experimental tryout of the PTs was made in order to determine the number of tasks that could reasonably be used. Initially, it was believed that eight problems could be used, and plans were drawn up to develop that many. However, because of the time, personnel and equipment constraints, it was concluded that only three problems could be realistically evaluated within the resources available.

It was concluded from the interviews with the experienced personnel that the AN/PPS-5 radar should be used as the equipment vehicle for this research. The other radars (except the FAAR) are programmed to be taken out of the Army inventory in the near future, being replaced with the AN/PPS-5. It was also determined that there were not enough FAAR mechanics in the Army, even worldwide, for testing purposes.

Two TMs and a school-produced job aid were obtained and reviewed in detail. These were:

TM 11-5840-298-12. Organizational Maintenance Manual Radar Set AN/PPS-5

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5

ST 30-40-32 (Sept 73) Introduction to Radar Sets AN/PPS-5 and AN/PPS-5A

Eight tasks were selected to be developed for the research evaluation. These included: five troubleshooting tasks, one removal and replacement task, a bench servicing task and an adjustment/alignment task. After it was determined that only three tasks would be feasible, these eight tasks were reviewed. The adjustment/Alignment problem presented difficulties. First, a reasonably difficult problem could take even a proficient technician longer than would be feasible for test purposes. Second, standardizing the amount of misadjustment/misalignment would be difficult. Third, a misadjustment/misalignment problem could present symptom information that could mislead technicians.

The bench servicing and removal/replacement tasks required the same kinds of job behaviors as the troubleshooting tasks. So it was concluded that the troubleshooting tasks would require almost all of the skills contained in the other tasks. Troubleshooting requires that the technician perform the following kinds of activities.

1. Operate the radar set.
2. Troubleshoot the radar set using starting procedures.
3. Troubleshoot the radar set using test equipment.
4. Remove and troubleshoot systems using test equipment.
5. Remove and troubleshoot component parts using test equipment.
6. Use written materials and schematics in troubleshooting.
7. Fill out DA forms.
8. Replace systems and components.

Specific malfunctions and their related symptom information were identified and described for five troubleshooting problems. Input was obtained from personnel at the USAICS in problem selection, since initial plans were to conduct all testing at Fort Huachuca. All problems could be identified using a special test set, MK-980 Test Facilities Kit. The problem also required that faulty components be inserted in the radar.

As the research progressed and attempts were made to try out the test problems, several difficulties arose. First, it was determined that there were not as many technicians at Fort Huachuca as first indicated. Personnel with 26C MOS were located at Fort Bragg, Fort Hood, Fort Bliss and White Sands Missile Range. However, it was determined that maintenance shops at these locations did not have all the necessary test equipment, specifically the MK-980. Therefore, some test problems were developed that did not require the use of the MK-980.

A second problem was concerned with insertion and removal of faulty components. When components are replaced on circuit boards (cards or chassis) the resoldering makes it obvious that the component has been inserted. Technicians, while in school, learn to use this kind of information to identify the malfunction. Additional concern was that specific malfunctions can cause damage to other parts of the radar. It was decided, then, to obtain circuit cards that had a specific malfunction and insert the entire card into the set. These cards are plug-in units and would not provide extraneous information that the resoldered component would. Cards with such malfunctions are sent to depot maintenance shops for repair, specifically to Sacramento Depot in California. An attempt was made to obtain several of these cards, but administrative time delays precluded their use in the field testing.

In summary, three troubleshooting problems were selected based upon pragmatic considerations—to fit the actual limitations that existed. Two problems did not require the MK-980, or the insertion of malfunction components that needed to be soldered in. One used a disconnected plug and the other used malfunctioning crystals that were inserted like fuses. The third problem required the MK-980 and was used at Fort Huachuca and at Fort Bliss only. (Fort Bliss finally obtained an MK-980.)

C. Performance Test Construction

1. Evaluation Manual. A combination of performance test formats reported in the literature was used in the development of the evaluation manual for this research. There are six sections to the manual (see Appendix D). The first part provides general instructions about performance testing to the evaluator. General procedures for preparation and administration of a test are also included. The next section is the performance objective for the task making up the test. The third section presents references to the specific procedures that are described in the TM for isolating the malfunctioning part. This is provided for the evaluator's information, and probably are not the procedures that would be followed by experienced technicians. In the interviews and subsequent discussions with experienced technicians, it was concluded that the specific sequence of troubleshooting procedures would vary with individuals. Therefore, the evaluator was instructed to look for "end products" of the troubleshooting activities rather than for a specific sequence of steps. The scoring procedures reflected this conclusion.

2. Administrative Requirements. The next section of the manual presents detailed instructions for administration of the test. Specific instructions for evaluating test performance are presented. The task is described in terms of what the technician must identify in his isolation procedures. There is also a description of what the examinee must demonstrate through his behaviors. Next, the test conditions, equipment, tools, and materials required for the test are listed. The test facilities themselves must meet several requirements for safe operating procedures. These are described, along with the qualifications of the test administrator and test evaluator. It was assumed that more than one examinee may be tested at one time, so duties were separated for administration and evaluation. Prior to beginning a test, the symptoms must be verified for each problem. This included checking the radar for its operational condition and ensuring that only the desired set of symptoms existed. A checklist was provided for this purpose. Next, the instructions to be read to the examinee are presented.

3. Evaluation Alternatives and Scoring Consideration. The last section covers the scoring of test performance. The literature had discussed two general approaches to evaluating performance--using some measure of product evaluation or some measure of process evaluation. Or some combination of the two. Products of task behavior could be measured in the following terms:

1. Time to complete the task.

2. Quality of the final work--in this case, in terms of whether or not the radar set works properly when the technician finishes the task.

3. Identification of a malfunctioning component, but not its replacement with a functioning component.

Process would be measured in terms of determining whether or not the examinee used the correct procedures, in an appropriate sequence, while completing a task. This evaluation was determined to be inappropriate for the troubleshooting task since there was not a specific set of procedures that are followed by experienced technicians. Therefore, a combination of subproducts were identified as a possible alternative to evaluating the troubleshooting process. It was determined that malfunctions are isolated from the radar set to a system, to a sub-assembly, to a stage and finally to a component. So, instead of one final test product, four subproducts could be identified. This was the evaluation approach for two of the three tasks used in this research.

In addition, it was concluded that maintenance performance could also be evaluated by scoring how test equipment was used and whether or not safe operating procedures were followed. Six pieces of test equipment were identified as being vulnerable to improper use. The specific improper actions that could damage a piece of test equipment were listed in a checklist. A checklist was also drawn that described unsafe operating procedures.

Each of the three evaluation sections were scored as satisfactory or unsatisfactory based upon a logically decided criterion. The Isolation of Malfunction section was scored satisfactory only if the malfunctioning component was correctly identified within the time limit. The Equipment Use section was scored satisfactory only if Action #A1 (Measures resistance with equipment turned on) was not committed and no more than two other improper actions were committed. The Safe Operating Procedures section was scored satisfactory if no more than three unsafe actions were committed.

VI. PERFORMANCE TEST EVALUATION

A. Evaluation Procedures

Once the performance test manuals were completed, the first step was to iron out any administrative difficulties and correct any difficulties in the instructions. Several experienced technicians who were qualified to serve as evaluators were given the manual and asked to administer the test. This led to several modifications and additions to the instructions which were made before actual test administrations. It was pointed out by these technicians that it would be difficult to administer this test at most locations other than at a school location. The primary problem was that most maintenance shops would not have all of the equipment and materials required for the test. In addition, most locations could not, without special preparation, meet the facilities requirements.

1. Evaluators. The field testing of the performance tests were conducted at four Army posts in the following order:

a. Fort Hood, TX
b. Fort Bragg, NC
c. Fort Huachuca, AZ
d. Fort Bliss, TX

In order to compare results across these four sites, a technical assistant on the research project served as one evaluator at all four

sites. Two additional evaluators were available at Fort Bragg and one additional at Fort Hood and Fort Bliss. Except for the technical assistant, all evaluators were Army enlisted personnel. All evaluators had considerable background experience in electronic maintenance and all were quite familiar with the AN/PPS-5 radar set and its required test equipment. In establishing the evaluation procedures, it became apparent that an evaluator of electronic maintenance performance must have a minimum amount of electronic maintenance experience in order to validly assess the use of test equipment and safe operating procedures. All evaluators were extremely competent and cooperative, which facilitated the data gathering effort.

At all locations data gathering had to be coordinated with ongoing job responsibilities of evaluators and examinees. At Fort Hood, the testing period was shortened due to a Battalion demonstration.

2. Examinees. When the 26C MOS was selected for use in this research, it appeared that an adequate number of personnel would be available at Fort Huachuca to meet testing requirements. Unexpected events, however, occurred as the project progressed. Two classes of 26C students were cancelled and other classes had reduced input. Several experienced technicians were transferred. Others did not wish to participate as test subjects because it had been several years since they had been on the equipment.

The only other sites in the country with both personnel and enough equipment for even minimal testing were Forts Hood, Bragg and Bliss.

A total of 43 technicians were tested. Their experience in electronic maintenance varied from none (except school training) to 120 months. Table 4 presents a distribution of experience range.

TABLE 4

ELECTRONIC MAINTENANCE EXPERIENCE
OF EXAMINEES

Experience in months	Number of Examinees
0 (students)	6
1-6	11
7-12	7
13-24	12
24+	7

All examinees were not tested on all three tests for several pragmatic reasons. Test equipment was not always available. Some individuals were available for only enough time for two tests. Equipment breakdowns could not be repaired in enough time to finish some testing in the time available. And delayed access to equipment did not permit preparation of equipment before test subjects arrived. Thirty technicians were tested on the first problem, 32 on the second and 40 on the third.

Background information was obtained on each subject. This included his job experience, education, other MOS experience, additional school experience, approximate number of radars repaired in last year and MOS test score. Only eighteen examinees had 26C MOS scores. The other 25 examinees either had not yet taken an MOS test or had taken a test for some other MOS. Scores ranged from 48 to 137, with an average score of 104.

When grouped by testing location the examinees differed in mean experience, MOS test scores and job ratings obtained from immediate supervisors at time of testing. This descriptive data is presented in Table 5.

TABLE 5

Experience Level, MOS Test Scores and Job Ratings of Examinees of Four Test Locations

		Test Location			
		Hood	Bragg	Huachuca	Bliss
Exp*	$\bar{x}$	28	30	8	22
	s.d.	10	40	8	27
	N	6	7	19	11
MOS	$\bar{x}$	92	103	127	86
	s.d.	8	33	9	27
	N	3	6	5	4
Job Rating**	$\bar{x}$	4.7	5.5	3.7	5.2
	s.d.	.5	.8	.98	.7
	N	6	7	19	11

* Experience is expressed in months of electronic maintenance experience.

** The immediate supervisor of each technician was asked to rate him on his overall job performance using the job performance rating scale from the Enlisted Evaluation Rating form. Scale values ranged from 0-6. Ratings, however, for the technicians ranged from 4-6.

Most of the examinees at Fort Huachuca had very little job experience. Most of them had just recently graduated from school. They were given low job ratings by their supervisor. The experienced technicians at the school had performed better on their last MOS test than did the experienced personnel at other locations. The large standard deviations of 40, 33, and 27 result from small numbers of subjects and a wide range of scores.

This descriptive data is presented as a means of further substantiating the requirement for standardization of these administration and test conditions. The literature had indicated the possible increase in variance due to interaction of individual differences and test conditions. Without standardized conditions and procedures, variation in performance test scores could be attributed to invalidity of the test, rather than to interaction effects.

3. Procedures. Generally, the field testing followed the same sequence of procedures at all locations. A meeting was held with individuals who were responsible for supporting the research. The research purpose and evaluation approach was described in detail (see Appendix D). Next, the specific administration and scoring procedures were reviewed with the evaluators. The next step was to locate and assemble the required equipment, tools and other materials. In most cases, this was taken care of prior to the research team visit. The test stations were then set up, arranging the equipment and tools in a standard arrangement. A different test station was set up for each test problem. Once this had been completed, the evaluation procedures were reviewed once again.

When a test subject arrived, he was first briefed as to the purpose of the research program. He was then read the instructions for the test. Almost all examinees went immediately to the problem without asking questions. After a few examinees had completed the testing, it was decided that two examinees could be tested simultaneously, which was done subsequently when two subjects were available at the same time. The evaluators placed themselves where they could observe both examinees at the same time.

Upon completion of a test, the examinee was moved away from the test station and the station was prepared for the next test. Examinees were not allowed to discuss the test problems between tests. In most cases, where two examinees were tested at the same time, they usually finished one test and started the next one at different times, so they had little opportunity to discuss the test. There was no evidence throughout testing that examinees had prior information concerning test problems.

B. Evaluation Problems

Several problems that arose during this research have been mentioned throughout this report. These problems will be summarized here. The primary problem was the location and coordination of equipment and personnel. Equipment was the most difficult to locate. Specifically, the MK-980 test kit was the least available. In some cases, this test equipment was reported as malfunctioning or not working at all. It was indicated that experienced personnel were not familiar with it and therefore, were not willing to use it. In other cases, radar sets that were available were not operating properly.

One problem that occurred several times during testing was than an unprogrammed problem cropped up in the radar system. If the evaluator had not been sufficiently experienced, the problems would

probably not have been noticed until the pre-test equipment check prior to the next test. As it turned out, two problems were solved without much delay and the other two with only a short delay in testing.

Another significant problem was in standardizing the test conditions. Only the Fort Huachuca location met the full requirements specified in the administration procedures (see Appendix D). Other locations lacked proper grounding of work space and equipment, lacked safety and first aid materials and did not have a full complement of available equipment.

It was also noticed that there were some differences in evaluator behavior. Several could not help but ask the examinees for information during the test, although they were instructed not to. Such questions as the following were asked: "What do you think?", "Have you located the problems?", "Why do you think it's that problem?". It was felt that such questions did not invalidate this data, but it does indicate that evaluators, unless well trained, may have some difficulty remaining completely objective.

C. Feasibility of the Use of Performance Tests

Definition of Feasibility. The first problem in evaluating the feasibility of using job sample, hands-on-equipment performance tests for measuring job proficiency is to define the term feasibility as it was used in this research.

There are the elements of test validity and reliability that must be included in the definition. With validity, the primary concern becomes the question of what criterion is appropriate for evaluating a job sample, hands-on-equipment performance test. The literature review indicated that content validation, with an adequate job analysis, would serve the purpose. The tasks selected for this research were determined to be important or critical by a sample of experienced technicians.

Reliability of performance test scores must also be considered in the definition of feasibility. For this research, reliability of scores was determined by obtaining measures of inter-rater (evaluator) reliability.

In this research project, administrative/logistical factors became a major consideration in the definition of feasibility. Design, construction and conduct of the actual test presented few problems. The location, assembling and preparation of equipment and materials all

had to be considered in establishing standardized conditions for testing, as well as the standardization of evaluator behaviors. These considerations were relevant because of the necessity of administering the performance tests at locations other than where conditions were ideal (Fort Huachuca).

A last issue that should be pointed out that would influence performance on performance tests is the familiarity of MOS holders with all of the equipment for which they are responsible. One examinee in this research stopped half way through the time allotted and said he had never worked with the equipment, but if he had an unlimited amount of time he could solve the problem. However, in the test situation, time is limited and allowances are not made for becoming familiar with the equipment. The point is that if an individual is to be given a performance test on any equipment for which he is responsible, he must be provided access to that equipment for practice.

Evaluation of Results. Test Performance--Four dependent variables were obtained on each of three performance tests. These were:

1. Time
2. Malfunction isolation
3. Use of test equipment
4. Safe operation procedures

Test A required the examinees to use the MK-980 test facilities kit to isolate an open capacitor. (For a detailed description of the tests, see the example in Appendix D.) A total of 30 examinees took this test. The malfunction was successfully identified by 16 (53%) of the examinees. All 30 were successful in their use of test equipment and all were satisfactory in the use of safe operating procedures. The average time of those who identified the capacitor as open was 34.24 minutes.

Test B was an open plug problem. Twenty one of 32 examinees (66%) correctly found the problem. It took an average of 38.24 minutes to successfully identify this problem. A total of 14 examinees used test equipment, and used it correctly. Again, all examinees were satisfactory in their safety procedures.

Test C was a typical field problem, the identification of a pair of weak crystals. Of the 40 examinees, 23 (58%) correctly identified the malfunctions. No one misused the test equipment. Everyone used safe operating procedures. The average time to successfully identify the problem was 32.08 minutes.

Of those examinees who did not successfully identify the malfunctions, all but two used the entire time (60 minutes) that was allotted. Both of these examinees stopped after about 30 minutes and gave up.

Validity. The primary approach taken to establish the validity of the three performance tests was to assure content validity. A check was made with each test subject to see if he thought the test represented his job. All examinees indicated that the troubleshooting problems were fair--that they expect to see those or similar problems on the job. Subsequently obtained information on actual numbers and types of malfunctions in the AN/PPS-5 radar set has provided further evidence of the validity of Test A. The crystal problem used in this research was reported to be the most frequently recurring malfunction in the field.

A second validation approach that was used was the mastery classification approach as suggested in the literature review. Mastery was defined using three external criteria--amount of job experience, supervisor ratings of job performance and MOS test score. In terms of job experience, those with more than 12 months of experience were classed as masters, those with 12 months or less as non-masters. The 12th month was selected as the dichotomization point because previous research by Williams and Whitmore (*28*) found that job performance scores began to level off after 12 months on the job.

All test subjects were rated by their immediate supervisor at the time the PTs were administered. The scale from the Enlisted Evaluation Report was used. This scale has six rating points varying in definition from unsatisfactory to outstanding. The ratings of the examinees varied from 3-6. Those who were given a rating of 5 or 6 were classed as masters. Those with a 3 or 4 were classified as non-masters.

The MOS test scores were dichotomized at a score of 100. Those above 100 were classed as masters and those below as non-masters for the purpose of this evaluation.

The Kappa coefficient was used to evaluate the relationships between the master/non-master classification on the pass-fail scores on the tests. Kappa makes no assumption as to the data distribution and it corrects for chance agreements. The Kappa coefficients are shown in Table 6.

TABLE 6

Relationships Between Job Experience, MOS Test Score, and Job Ratings and Test Performance (Kappa Coefficient)

Test	Job Experience	MOS Score	Job Rating
A	-.38*	.52*	-.36*
B	-.02	.53*	.38*
C	.25	.19	.16

* $p < .05$

These results indicate that for Test A the technicians classified as non-masters by experience and job ratings performed better on the test. This is an explainable result in that Test A required the use of the MK-980 test facilities kit and many of the experienced technicians (masters) had not used or received instructions on how to use this equipment. The technicians who had received higher job performance ratings were also the more experienced.

Table 6 indicates that technicians classed as masters on the basis of job rating and MOS score performed better on Test B than non-masters. Test B used the crystal problem commonly experienced in the field.

The significant relationship between MOS test scores and performance on Test A and B confirms earlier work by Williams and Whitmore (*28*). They had found positive relationships between written test scores and performance test scores.

No empirical confirmation of the content validity was found in Test C using these mastery definitions.

Reliability. The reliability of the tests was looked at two ways. The first was by correlating pass/fail performance on all three tests with each other. These relationships are presented in Table 7.

TABLE 7

Correlation Matrix for Performances on All Three Tests (Kappa)

		Test	
		B	C
Test	A	.55*	.39*
	B		.42*

* $p < .05$

Intertest reliability was found to be significant at the .05 level. This indicated to some degree that the technicians' performance on one test could be predicted from performance on another.

The second assessment of reliability used interrater agreement evaluations. As indicated earlier, only one rater rated all examinees. When the satisfactory-unsatisfactory scoring criteria were used to compare raters, there was 100% agreement. All examinees met the criteria for success on the Use of Test Equipment section and on the Safe Operating Procedures section. The criteria for a satisfactory score on the Action section was clear cut, and the examinees' performance was obvious to the evaluators.

When the process scores for the raters were compared, some differences were noted between rater 1 and the other raters. The correlation between this evaluator and the others for this data is shown in Table 8.

TABLE 8

Interrater Correlation Matrix
(Rater 1 with Raters 2-7)

Rater					
2	3	4	5	6	7
.55	.55	.61	.56	.84	.70

In addition, evaluators 4 and 5 rated the same examinees. The correlation of these ratings was .96. A combined interrater reliability of .73 was obtained.

Time. The test results were also looked at in terms of the time to perform measures. Table 9 presents the mean times for the technicians who successfully performed on each of the three tests for three levels of experience. There were no significant correlations found between job experience and time to perform.

TABLE 9

Mean Time for Successful Performance
by Experience Level
(Minutes)

Months Experience	Test		
	A	B	C
0-6	32.0	42.7	31.4
6-12	37.6	35.5	32.6
12+	25.0	36.3	32.9

Similar results were found when the time scores of those who successfully completed the tests were compared across job rating. Table 10 presents the mean time of performance by job rating for each test.

TABLE 10

Mean Time for Successful Performance
by Job Rating
(Minutes)

Job Rating	Test A	Test B	Test C
3 & 4	33.9	35.0	33.8
5 & 6	33.6	36.3	32.0

VII. SUMMARY AND CONCLUSIONS

A. General Conclusions

The most obvious conclusion that can be drawn from this research is that if the criteria for evaluating electronic maintenance performance are clearly defined, different evaluators will reach the same conclusion concerning performance. For the product evaluation approach (satisfactory vs. unsatisfactory test performance) there was 100% agreement between the evaluators on an individual's performance. The authors are not aware of previous research where this results was reported. This would appear to be an important issue, if performance tests are to be used to evaluate job performance where different evaluators may be evaluating test performance at different locations. From this research, it can be concluded that the same conclusions about an individual's performance on these PT would be arrived at independent of who the evaluator is or where the testing is conducted.

The evaluation approach using process scores did not yield the same level of agreement as the product approach. A minimum interrater reliability coefficient of .73 was found here. It can be concluded that evaluators can agree on whether or not a technician can do a job, but do not agree to the same extent on their evaluation of how the man does the job. Previous research (*71*) obtained data on a process evaluation approach where an examiner and an observer recorded the time at which technicians performed task activities. They found agreement between the records 80 percent of the time. The present research found a lower figure, 53%.

Research by Baldwin, et al. (*71*) and Williams and Whitmore (*28*) had earlier found positive relationships between electronic maintenance experience and test performance on troubleshooting tasks. This is a result that would be expected if it is assumed that skill proficiency is developed as the individual becomes familiar with operational and test equipment, and as he practices the behaviors making up job skills. As reported in the skill acquisition section, these assumptions appear valid. Therefore, if a test is a valid representation of the job, the more experienced technicians should do significantly better than inexperienced technicians. This was not confirmed in this research. It was assumed that job knowledge was a requirement for proficient job performance. Technicians with higher MOS scores did perform better on Tests A and B. Therefore, if performance by technicians with more job knowledge can be viewed as a criterion, two of the three PTs can be assumed to be valid for measuring job proficiency. This conclusion on validity is in addition to the content validation approach that was taken in the development of the PTs.

It had been assumed that job proficiency of electronic maintenance technicians could be defined by performance of a required task in a minimum time using test equipment and tools properly, and using safe operating procedures. In this research, the only dependent measure that differentiated between examinees was performance of the task action. Across tests, 60 technicians passed and 42 failed on the action element. There were no unsatisfactory scores on the test equipment and safe operating procedure sections. There was a spread of the times required for successful completion of the test from 9 to 60 minutes. This range of times did not correlate with amount of experience. All but two of those who failed took the maximum allowed time. In some cases, it could be argued that some who did not identify the malfunction would have if they had been given more time. But this is a supposition. Otherwise, time as a dependent measure of job proficiency was not confirmed, other than to say 60 percent of the sample correctly identified the malfunction in 60 minutes or less.

The conclusion here is that the correct isolation of a malfunction is the most discriminating dependent variable that can be used in performance test evaluation of electronic maintenance proficiency.

From the interviews of technicians concerning where they acquired their skills, it can be concluded that the skills that lead to proficiency performance in a complex technical MOS are introduced in a training program but developed while actually performing the job tasks. Therefore, to develop full proficiency in an MOS, a technician must be assigned to a variety of duty positions in his MOS.

B. Use of Performance Tests

Two issues were of concern in this research for the use of job sample, hands-on-equipment performance tests. The first was using PTs for evaluating job proficiency in a complex technical MOS. The second was using PTs as criterion measures against which to evaluate the validity of synthetic or simulated tests. The first issue involves the question of pragmatic factors such as logistical support, generalizability of test results, standardization of conditions, and cost effectiveness as well as the psychometric considerations of validity and reliability. The second issue is primarily concerned with just the psychometric considerations.

It would appear from the difficulties encountered in this research, that it would be pragmatically unfeasible to use PTs for evaluating electronic maintenance job proficiency at other than the ideal location where resident instruction is given for the MOS. This assumes that temporary testing facilities would be set up at other locations. This conclusion is based on a probable lack of a full complement of test equipment and materials at maintenance sites other than the school. In addition, it assumes that a formal test location would have to meet standardized test conditions, to include test station set up and safety criteria. This would entail additional preparation costs at most sites.

There is also the question of tying up and possibly damaging the operational equipment that would be used in the PTs. This fear was expressed by several NCOs responsible for operational equipment. This is only a valid issue if there is a lack of surplus equipment, which was true for the AN/PPS-5 radar set. However, previous research conducted by Williams and Whitmore (*28*) used operational equipment without incident.

The question of generalizing the results from a PT to total job performance is a point that must be considered in establishing the size of the PT. Usually testing time is limited. Therefore, only a limited sample of job tasks can be included in testing. This generalization question becomes more critical as the number of actual job tasks increases, which is primarily a function of the number of pieces of equipment for which a maintenance technician is responsible. For the 26C MOS, the job activity matrix in Table 3 could be used with the three radars to identify the task pool from which to select test problems. This would result in a very large item pool, counting only the important and critical tasks. As for the results of this research, it would appear that for the AN/PPS-5 radar, generalization from test to the job may not be a problem, since significant, although moderate,

inter-test correlations were found. The question remains as to generalization across other equipment.

As for using PTs as criterion measures, it is assumed that simulated test validation would take place under the best conditions, so the pragmatic constraints should not be an issue. It can be concluded that if other PTs are developed using procedures similar to those used here, then they would be valid and reliable and could serve as criterion measures for test validation.

C. Generalization to Other Complex Technical MOS

The question of generalizing these results to other MOS addresses the issue using PTs to evaluate job skill proficiency. This discussion is included to point out that the 26C MOS does not include as broad a coverage of equipment responsibility as other technical MOS, nor is the equipment as complex as in other MOS. The issue here is derived from the fact that all individuals holding an MOS are responsible for all equipment in that MOS. For example, the 26W MOS (to which 26C is a feeder MOS), is responsible for more than 20 major pieces of equipment. In their service career, most technicians with the 26W MOS see only a few of these pieces of equipment. There would be a high probability that the majority of PT tasks used to evaluate job skill proficiency of a 26W technician may use equipment (both test and operational equipment) that he may never have used or even seen.

In summary, it would appear that the pragmatic problems discussed above for the use of PTs for the 26C MOS would multiply as the complexity of the MOS is increased.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the development and evaluation of prototype hands-on equipment, job sample performance tests for a high skilled technical MOS. An electronic maintenance MOS (26C20) was used as the research vehicle. The results lead to the conclusion that valid and reliable performance tests could be constructed, but that equipment, facilities, and standardization requirements reduce the feasibility of their use at other than an ideal location, such as a U.S. Army school.

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APPENDIX A

CMF 26

Combat Area Surveillance Radar

MOS 26C

CMF 26
COMBAT AREA SURVEILLANCE RADAR REPAIRMAN

MOS 26C

Summary

Performs organizational, direct, and general support maintenance on ground surveillance radar and support and depot maintenance on light air defense pulse doppler radars and associated equipment.

Duties

MOSC 26C20: Performs organizational maintenance on ground surveillance radar sets AN/PPS-4A, AN/PPS-5, AN/TPS-25A and AN/TPS-33. Cleans components of dust, rust, and foreign matter. Assists in reconnoitering position areas, selection of sites, and emplacement of radars and associated equipment. Employs organizational test equipment. Employs prescribed maintenance manuals, repair parts, and special tool list. Employs administrative and supply procedures associated with the maintenance mission. Interprets schematics and technical literature. Recognizes electronic countermeasures and applies appropriate electronic counter-countermeasures.

MOSC 26C30: Must be able to perform the duties of Combat Area Surveillance Radar Repairman (26C20). *Performs direct and general support maintenance on ground surveillance radar equipment and support and depot maintenance on light air defense pulse doppler radars.* Test-operates malfunctioning equipment. Refers to circuit diagrams and makes detailed tests through stages of equipment utilizing voltmeters, ohmmeters, signal generators, oscilloscopes, and other testing devices. Identifies common malfunctions and nonfunctions. Determines cause of breakdown and extent of required maintenance. Replaces faulty components, including vacuum tubes, resistors, capacitors, and transistors. Adjusts relays, dials, and controls using common or specialized hand tools. Performs modification work orders in accordance with prescribed procedures. Advises organizational maintenance personnel on changes in maintenance equipment as a result of modification work orders. Keeps tools and test equipment in operating condition. Keeps worklogs current and prepares supply requisitions. Applies servo, timing, and gating circuitry principles and procedures. Employs the procedures for biasing vacuum tubes and alining radar transmitting and receiving chassis. Performs direct support, general support, and depot maintenance on light air defense and ground surveillance radars. Interprets circuit diagrams, block diagrams, schematics, and technical manuals applicable to light air defense and ground surveillance radars. Detects malfunctions and potential source of breakdown from wave tracings on radar consoles. Troubleshoots malfunctioning equipment by sectionalization, localization, and isolation of malfunction to individual components or associated group of components.

APPENDIX B

Interview of Experienced Technicians

and

Checklist of Frequently Performed Tasks

ASSALT

INTERVIEW OF EXPERIENCED TECHNICIANS

INTRODUCTION

We are from the Fort Bliss office of the Human Resources Research Organization (HumRRO). We have been contracted by the Army Research Institute (ARI) to study methods of developing "hands-on" performance tests for evaluating the job proficiency of high-skill technical personnel. Job sample performance tests will eventually replace the current written MOS proficiency tests. The current written tests are to a great extent job knowledge tests and some people even dispute their relationship to MOS job tasks. Before we can actually build a performance test, we have to figure out what should be included, since we can't test on all job tasks. As a first cut, we are obtaining various kinds of information about technical jobs.

26C is one MOS we are looking at in this development project. We would appreciate your cooperation in providing information about jobs in this MOS. I am going to ask several kinds of questions and I want you to assume that I know practically nothing about the 26C MOS jobs.

Are there any questions?

ASSALT

INTERVIEW OF EXPERIENCED TECHNICIANS

General Information:

RANK:

MOS:

TIME IN SERVICE:

TIME IN MOS:

DUTIES/POSITIONS IN MOS:

SCHOOLS ATTENDED IN SERVICE:

SPECIFIC JOB EXPERIENCE INFORMATION:
Describe the job of the 26C in terms of major work categories.
(If he starts to do it by equipment, say I mean like troubleshooting)

Percent (%) of time spent on MOS duties:

What non-MOS duites are performed most often?

What equipment is 26C responsible for:

What test equipment do you use most often?

Documents?

Forms?

(If not mentioned above, ask:)

Do you supervise others?

In MOS?

Out of MOS?

Do you train others on the job in MOS?

Do you evaluate MOS performance?

What malfunctions have you dealt with?

Most common malfunctions (by major equipment)?

Most difficult malfunctions to correct?

How long to get equipment back-up?

Describe your troubleshooting procedures:

What kinds of skills and knowledges does a 26C need? Where are they learned? Do any apply across equipment?

Describe a performance test you would design for 26C if you had:

8 hours:

2 hours:

[GO OVER THE TASK LIST AND GET HIS FEELING ABOUT THE IMPORTANCE OF EACH ITEM--

0 -- not important

1 -- nice to know

2 -- important to job

3 -- critical to job.]

Checklist of Frequently Performed Tasks

26C MOS TASKS

CATEGORY	# TASKS
Prepare paperwork	34
Use written material	14
Use Basic Electronics	61
Equipment related	220
	329

Tasks performed by 50% or more of responding incumbents.

	% DO	% DO FREQUENTLY
Maintain Library of Publications	60	19
Requisition TM Changes	50	16
Use classified material	51	25
Make entries in Log Book	63	28
Review entries in Equipment Log Book	75	19
Request Repair Parts	84	55
Fill out forms in accord with TM 38-750	79	50
Use ESC TM	71	38
Use DA Pam:		
310-4	50	16
310-7	51	16
Use DA Form:		
2404	84	63
2407	89	61
2408	55	16
314	59	25
Use Direct Supply Unit	67	39
Use Technical Supply Unit	67	35
Use Supply procedures	74	44
Requisition Authorization Stock	64	19
Fill out requisition	70	26
Determine voltage by calculation	79	40

(continued)

Tasks performed by 50% or more of responding incumbents (continued).

	% DO	% DO FREQUENTLY
Determine resistance by calculation	81	35
Determine capacitance by calculation	75	37
Determine Frequency by measurement	86	57
Determine Current by measurement	89	60
Determine Current by calculation	77	30
Use Radar fundamentals	91	51
Use optics fundamentals	54	12
Troubleshoot:		
receiver	88	44
transmitter	86	46
indicator	85	36
synchronizer	68	28
power supplies	84	39
recorder	53	16
AFC Circuit	84	39
STC Circuit	63	28
AGC Circuit	81	35
IF Strip	79	35
Antenna base	67	25
Video circuit	79	23
Synchronizer Circuits	68	21
Range marker circuits	77	29
AC Servo systems	71	22
DC Servo systems	72	22
Synchro systems	70	25
Automatic Switching Circuits	71	19
IF Preamplifier	69	21
Control and Protective Circuits	72	21
Metering Circuits	78	26
Video Driver Module	67	13
Azimuth Gear Train Assembly	66	14
Elivation Gear Train Assembly	67	16
Audio Circuits	76	28

(continued)

Tasks performed by 50% or more of responding incumbents (continued).

	% DO	% DO FREQUENTLY
Troubleshoot (continued):		
Range strobe circuits	71	14
Magnetic Amplifier Circuits	63	19
MTI Circuits	50	16
Analyze:		
System performance	79	33
Complex waveforms	62	22
Block diagrams	81	28
Transmitter circuitry	81	24
Receiver circuitry	79	21
Schematic Diagrams	82	36
Install/replace:		
Transformers	65	20
Tubes	70	26
Crystals	73	27
Resistors	72	26
Capacitors	69	26
Coils	66	20
Wiring	74	30
Test for:		
Shorts	82	39
Opens	77	40
Change in resistance	74	32
Cold Soldering Joints	65	26
Movement of Antenna for Elevation	75	28
Use proper soldering technique	78	48
Use schematic diagram in isolating faults	83	50
Isolate faults in wiring or cables	81	30
Isolate mal-alignment of equipment	78	33
Isolate equipment failure to a faulty component	77	44
Start set transmitting	79	34
Check for proper scope presentation	74	36
Select target for orienting purposes	64	21

Tasks performed by 50% or more of responding incumbents (continued).

	% DO	% DO FREQUENTLY
Orient Antennas	66	16
Perform modification work order	67	17
Operate range calibrators	62	22
Operate Audio oscillator	67	19
Adjust:		
for proper magnetron current	74	32
scope for clearness of presentation	74	38
Generator output	58	25
Transmitter power output	71	28
Operating frequencies	66	28
Equipment voltages	78	33
Power supplies AN/TPS-33	55	12
Align:		
Indicator	52	18
Transmitter	60	23
Receiver	56	23
AGC Circuit	55	18
IF Strip	52	21
Audio circuits	56	18
AGC Circuits	57	16
Receiver AN/TPS-33	52	7
Transmitter AN/TPS-33	52	7
Repair:		
Range marker circuits	59	14
AC Servo systems	54	18
DC System	68	21
Synchro systems	51	16
AFC Circuits	68	19
Automatic switching circuits	53	11
IF Pre-amplifier	52	9
Metering circuits	59	10
Elevation Gear Train Assembly	55	17
Azimuth Gear Train Assembly	57	19

(continued)

26C MOS TASKS (page 5)

Tasks performed by 50% or more of responding incumbents (continued).

	% DO	% DO FREQUENTLY
Repair (continued):		
AFC Circuits	64	21
Auto Circuits	55	16
Range strobe circuits	51	5
AGC circuits	62	14
Radar power sources	51	15
Inspect:		
AN/PPS-4A for deficiencies	56	23
Fuses on AN/PPS-4A	55	12
Cables on AN/PPS-4A	56	19
AN/PPS-5; AN/PPS-5A for deficiencies	53	19
Cables AN/PPS-5 (-5A)	52	14
Operate:		
AN/PPS-4A under maintenance conditions	50	13
AN/PPS-5 (-5A) under maintenance conditions	50	16
perform operational checks:		
AN/PPS - 4A	56	14
AN/PPS - 5 (-5A)	50	19
Test Equipment:		
Test set TV-7	67	
TS-352	81	
AN/USM-281	53	
Radar Test set TS-147	50	
Tools:		
Wire Cutter	83	

APPENDIX C

Performance Objectives

MOS 26 C

TASK:

Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set.

CONDITIONS:

Test equipment required is listed in Para. 9-12, TM 11-5840-298-35 and will be available as required. Para. 10-1 through Para. 10-5, TM 11-5840-298-12, will be read before starting. Start troubleshooting procedures by using Para. 10-6, TM 11-5840-298-35, STEP-BY-STEP Troubleshooting Chart Based on Starting and Checkout Procedures for Complete AN/PPS-5, ref. TM 11-5840-298-35, TM 11-5840-298-12. TMs on test equipment and tools will be available as required.

Testing of troubleshooting performance can start under the following conditions: Set up the Radar AN/PPS-5(A) as described in TM 11-5840-298-12 USING Power Supply PP-4450/PPS-5 instead of Battery Box Cy-3871/PPS-5. Mount the Dummy Load in place of Antenna AS-1394/PPS-5. Set the switch-breaker on Power Supply PP-4450/PPS-5 to OFF. Take cover and case off of the control indicator (Para. 20-2, TM 11-5840-298-35) and open the door of the receiver-transmitter at the rear of the control indicator. Disable interlock switch S3613. Set up all test equipment that will be needed. Set radar controls as directed in Para. 3-3, TM 11-5840-298-12. Start troubleshooting procedures with Step 1, Para. 11-9, TM 11-5840-298-35 (Step 3 below).

STANDARDS:

You will perform the following steps using STEP-BY-STEP procedures outlined in TM 11-5840-298-12 and in TM 11-5840-298-35:

1. Insure all switches and controls are set for troubleshooting per Figure 3-3, Preliminary control settings, TM 11-5840-298-12.
2. Set up and use test equipment to be used for troubleshooting as outlined in TM 11-5840-298-12 and equipment TMs.
3. Review DA Form 2407 (TM 38-750) before starting troubleshooting.
4. Verify conditions stated on DA Form 2407 (TM 38-570) by performing a complete checkout of the AN/PPS-5(A) Radar system, making additional notes on troubles found.
5. Perform procedures, Para. 10-6, Troubleshooting Chart Based on Starting and Checkout Procedures for Complete AN/PPS-5, TM 11-5840-298-35, to isolate to a major assembly (antenna, transmitter-receiver, etc.).

(continued)

TASK -- Continued

6. Isolate fault symptoms to a sub-assembly, using the CHAPTER listed for this system in TM 11-5840-298-35 to locate the card and/or component.
7. Follow specific STEP-BY-STEP procedures for troubleshooting specific sub-assemblies.
8. Remove and replace parts as necessary (ref. TM 11-5840-298-35 for system being serviced).
9. Bench service specific sub-systems as required (ref. TM 11-5840-298-35 for system being serviced).

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Perform Transmitter System Troubleshooting and Repair on the RADAR SET AN/PPS-5(A).

a. Perform Troubleshooting on Transitter System.

CONDITIONS:

Test equipment required is listed in Para. 9-12, TM 11-5840-298-35, and will be available as required. Para. 10-1 through Para. 10-5, TM 11-5840-298-12, will be read before starting. Start troubleshooting procedures by using Para. 10-6, TM 11-5840-298-35, STEP-BY-STEP Troubleshooting Chart Based on Starting and Checkout Procedures for Complete AN/PPS-5, ref. TM 11-5840-298-35, TM 11-5840-298-12. TMs on test equipment and tools will be available as required.

Testing of troubleshooting performance can start under the following conditions: Set up the Radar AN/PPS-5(A) as described in TM 11-5840-298-12 USING Power Supply PP-4450/PPS-5 instead of Battery Box Cy-3871/PPS-5. Mount the Dummy Load in place of Antenna AS-1394/PPS-5. Set the switch-breaker on Power Supply PP-4450/PPS-5 to OFF. Take cover and case off of the control indicator (Para. 20-2, TM 11-5840-298-35) and open the door of the receiver-transmitter at the rear of the control indicator. Disable interlock switch S3613. Set up all test equipment that will be needed. Set radar controls as directed in Para. 3-3, TM 11-5840-298-12. Start troubleshooting procedures with Step 1, Para. 11-9, TM 11-5840-298-35 (Step 3 below).
WARNING: Extremely dangerous voltages exist in this equipment. Turn OFF Power and ground capacitor C609 before making test on block 600.

STANDARDS:

You must perform the following steps in sequence:

1. Prepare the assembled transmitter system for troubleshooting by:
   a. Removing the antenna and installing the Dummy Load on the feedhorn coupling at the receiver-transmitter.
   b. Open the access door on the back of the transmitter-receiver.
   c. Set the radar controls as directed in Para. 3-3, TM 11-5840-298-12.
2. Set up all required test equipment, ref. Para. 11-7, Test Equipment Required to Troubleshoot Transmitting System, TM 11-5840-298-35.
3. Review DA Form 2407 (TM 38-750) before beginning troubleshooting procedures.
4. Verify conditions stated on DA Form 2407 (TM 38-750), making notes on additional troubles found and use this information as guidance in troubleshooting the system.

TASK -- Continued

5. Troubleshoot the transmitting system using the steps in Para. 11-9, TM 11-5840-298-35 according to the following procedures:
   a. Locate the test point given in Step 1.
   b. Connect the test equipment and set the controls on the test equipment as directed in the Test equipment column.
   c. Set the controls on the radar set as directed in the Radar set controls column.
   d. Compare the indications obtained on the test equipment with the indications that are given or referenced in the Normal indications column.
   e. If the indications obtained on the test equipment are normal, proceed either to the next step or do as directed in the Normal indications column.
   f. If the indications obtained are abnormal, proceed as directed in the corrective measures column, referring to the information in Para. 11-1 as necessary.
6. Perform transmitted power measurement procedures, ref. Para. 11-10, Measurement of Transmitted Power, TM 11-5840-298-35.
7. Turn OFF and disconnect all equipment and cables.
8. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) Radar Set to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Perform Transmitter System Troubleshooting and Repair on the Radar Set AN/PPS-5(A).

b. Perform removal and replacement of parts in the Transmitting System.

CONDITIONS:

Tasks 1 and 2a must have been performed before starting this task. One or more parts will have been identified as malfunctioning or requiring additional testing.

STANDARDS:

You must perform the following steps in sequence:

1. Review and verify conditions stated on DA Form 2407 (TM 38-750) making any additional remarks on troubles found and use the information as a guidance in troubleshooting the system.
2. For removal and replacement of the Magnetron follow procedures in Para. 11-12, Removal and replacement of Magnetron V101, TM 11-5840-298-35.
3. For removal and replacement of Block 600 Modulator follow procedures in Para. 11-13, Removal and replacement of Block 600 Modulator, TM 11-5840-298-35.
4. For removal and replacement of Block 3300 Interlock Panel follow the procedures in Para. 11-14, Removal and replacement of Block 3300 Interlock Panel, TM 11-5840-298-35.
5. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) Radar Set to using unit. If required, complete testing on replaced parts.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maitnenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK -- Continued

5. Troubleshoot the transmitting system using the steps in Para. 11-9, TM 11-5840-298-35 according to the following procedures:
   a. Locate the test point given in Step 1.
   b. Connect the test equipment and set the controls on the test equipment as directed in the Test equipment column.
   c. Set the controls on the radar set as directed in the Radar set controls column.
   d. Compare the indications obtained on the test equipment with the indications that are given or referenced in the Normal indications column.
   e. If the indications obtained on the test equipment are normal, proceed either to the next step or do as directed in the Normal indications column.
   f. If the indications obtained are abnormal, proceed as directed in the corrective measures column, referring to the information in Para. 11-1 as necessary.
6. Perform transmitted power measurement procedures, ref. Para. 11-10, Measurement of Transmitted Power, TM 11-5840-298-35.
7. Turn OFF and disconnect all equipment and cables.
8. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) Radar Set to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the RF System.

CONDITIONS:

STANDARDS:

You must perform the following steps in sequence:

1. Set up all required test equipment.
2. Review and verify conditions stated on DA Form 2407 (TM 38-750) noting any additional troubles and use this information as guidance in troubleshooting the RF System.
3. Troubleshoot the RF System (Para. 12-2, Troubleshooting Information, and Para. 12-3, RF System symptom troubleshooting chart, TM 11-5840-298-35).
4. If necessary, remove and replace the crystal protector (Para.12-5, Removal and replacement of crystal protector, TM 11-5840-298-35).
5. Turn OFF and disconnect all equipment and cables.
6. Complete DA Form 2407 and DA Form 2408-5 (TM 38-750) and return the repaired AN/PPS-5(A) Radar Set to using unit if repairs are completed.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

DA Form 2408-5.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Perform Transmitter System Troubleshooting and Repair on the Radar Set AN/PPS-5(A).

d. Adjust and align the transmitter system.

CONDITIONS:

A transmitter system from an AN/PPS-5(A) Radar Set that has been repaired but not adjusted or aligned will be available.

STANDARDS:

You must perform the following procedures:

1. Set up test equipment as in Figure 11-4, TM 11-5840-298-35.
2. Adjust the transmitter system trigger amplitude (Para. 11-15, TM 11-5840-298-35).
3. Adjust transmitter frequency (Para. 11-15b, TM 11-5840-298-35).
4. Complete DA Form 2407 (TM 38-750).

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Receiver system troubleshooting and repair of the AN/PPS-5(A) radar set.

a. Troubleshoot the receiver system.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) radar set, must be used to perform this operation. While troubleshooting the receiver system NO other RADARS are operating nearby. (Damage to the mixer crystals may occur when the crystal protector Tube V102 is NOT operating from a strong RF signal.)

STANDARDS:

You must perform the following steps:

1. Prepare the receiving system for troubleshooting by:
   a. Setting up and connecting all required test equipment (Para. 13-6 and 13-7(a), TM 11-5840-298-35).
   b. Set the controls and turn the equipment on as specified in Para. 13-7(b), TM 11-5840-298-35.
   c. After a 5-minute warm-up period, reset external power output to 24 volts.
2. Review and verify information on DA Form 2407 (TM 38-750) by performing test, ref. Para. 13-3, Normal Test Meter Indications, TM 11-5840-298-35, and make additional symptom information notes to use as guidance in troubleshooting.
3. Troubleshoot the receiver system by performing necessary receiver system tests (Para. 13-8, Receiving System Troubleshooting Chart, TM 11-5840-298-35) according to the following procedures:
   a. In the Symptom column of the chart, find the symtom that describes the radar set malfunction observed.
   b. Follow the Corrective measures procedure opposite the Symptom, always starting with the first step of the procedure opposite the symptom.
   c. After each step of a Corrective Measures procedure has been performed, check to see if the symptom has been remedied. If it has not, proceed to the next step.
4. Turn off and disconnect all equipment and cables, and return them to the proper storage areas.
5. Complete DA Form 2407 (TM 38-750) and return the repaired radio set to the using unit.

(continued)

TASK NO. -- Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Receiver system troubleshooting and repair of the AN/PPS-5(A) radar set.

b. Perform removal and replacement of components in the receiver system.

CONDITIONS:

Task 1 and 4a must have been performed before starting this task. One or more parts will have been identified as malfunctioning or requiring additional testing.

STANDARDS:

You must perform the following steps in sequence:

1. Review and verify conditions stated on DA Form 2407 (TM 38-750); make any additional remarks on troubles found and use the information as a guidance in troubleshooting the system.
2. For removal and replacement of receiver system components, follow the procedures referenced below for each component.
   a. Block 100 Tr assembly, Para. 13-10 and 13-11, TM 11-5840-298-35.
   b. If mixer crystals, Para. 13-12 and 13-13, TM 11-5840-298-35.
   c. AFC mixer crystals, Para. 13-14, TM 11-5840-298-35.
   d. LO Tube V103, Para. 13-15 and 13-16, TM 11-5840-298-35.
   e. AFC Varactor tuner CR106, Para. 13-17 and 13-18, TM 11-5840-298-35.
   f. Varactor Multiplier CR105, Para. 13-19 and 13-20, TM 11-5840-298-35.
   g. Isolator Z102, Para. 13-21 and 13-22, TM 11-5840-298-35.
   h. AFC Mixer Assembly, Para. 13-23 and 13-24, TM 11-5840-298-35.
   i. Lo assembly, Para. 13-25 and 13-26, TM 11-5840-298-35.
   j. Frequency multiplier assembly, Para. 13-27 and 13-28, TM 11-5840-298-35.
   k. Signal mixer assembly, Para. 13-29 and 13-30, TM 11-5840-298-35.
   l. Circulator Z101, Para. 13-31 and 13-32, TM 11-5840-298-35.
   m. Block 200-1, IF preamplifier, Para. 13-33 and 13-34, TM 11-5840-298-35.
   n. Block 200-2, AFC Preamplifier, Para. 13-35 and 13-36, TM 11-5840-298-35.
   o. Block 300, IF amplifier, Para. 13-37 and 13-38, TM 11-5840-298-35.
   p. Block 800, AFC amplifier, Para. 13-39 and 13-40, TM 11-5840-298-35.

TASK NO. -- Continued

3. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) radar set to using unit. If required, complete testing on replaced parts.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP.

TEC II Lesson No.

TASK:

Receiver system troubleshooting and repair of the AN/PPS-5(A) radar set.

c. Bench service the components in the receiver system of the AN/PPS-5(A) radar set.

CONDITIONS:

Components requiring bench servicing and removed from an AN/PPS-5(A) radar set will be available.

STANDARDS:

You must perform the following general procedures when bench testing components of the receiver system:

1. Review and verify the information on DA Form 2407 (TM 38-750).
2. Set up the required test equipment.
3. Connect the component for bench servicing.
4. Bench service the component following all notes.
5. Remove and replace all malfunctioning parts.
6. Bench adjust and test the component.
7. For specific procedures for each component see paragraphs from TM 11-5840-298-35, referenced below:
   a. Block 100 TR assembly, Section VI, Para. 13-53 - 13-57.
   b. Block 200-1, IF Preamplifier, Section VII, Para. 13-58 - 13-65.
   c. Block 200-1, AFC Preamplifier, Section VIII, Para. 13-66 - 13-73.
   d. Block 300, IF Amplifier, Section IX, Para. 13-74 - 13-81.
   e. Block 800, AFC Amplifier, Section X, Para. 13-82 - 13-89.
8. Complete DA Form 2407 (TM 38-750) and return the repaired component to the using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP.

TEC II Lesson No.

TASK:

Receiver system troubleshooting and repair of the AN/PPS-5(A) radar set.

d. Adjust and align the receiver system.

CONDITIONS:

A receiver system from an AN/PPS-5(A) radar set that has been repaired and reassembled but not adjusted or aligned will be available.

STANDARDS:

You must perform the following procedures:

1. Set up required test equipment (Para. 13-42, TM 11-5840-298-35).
2. Adjust and align the following components during bench servicing.
   a. Block 300, IF Amplifier assembly (Para. 13-80, TM 11-5840-298-35).
   b. Block 800, AFC Amplifier (Para. 13-88, TM 11-5840-298-35).
3. Adjust the current in Lo Cathode R105 (Para. 13-43, TM 11-5480-298-35).
4. Adjust the bias in Varactor Multiplier R103 (Para. 13-44, TM 11-5840-298-35).
5. Align local osscilator V103 (Para. 13-45, TM 11-5840-298-35).
6. Align Varactor Multiplier Alignment (Para. 13-46, TM 11-5840-298-35).
7. Adjust the bandpass filler screw (para. 13-46.1, TM 11-5840-298-35).
8. Make AFC Adjustments (Para. 13-47, TM 11-5840-298-35).
9. Complete DA Form 2407 (TM 38-750), and return the repaired receiver system to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP.

TEC II Lesson No.

TASK:

Troubleshoot and repair the Range Finding System of the AN/PPS-5(A) Radar Set.

a. Troubleshoot the Range Finding System.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation.

STANDARDS:

You must perform the following steps:

1. Set up the Range Finding System for troubleshooting with the appropriate test equipment (ref. para. 14-4 and Figure 14-2, TM 5840-298-35).

2. Review and verify the information on DA Form 2407, making note of additional information and use it as guidance in troubleshooting.

3. Troubleshoot the Range Finding System with the Control Indicator (ref. para. 14-5, TM 5840-298-35, by finding the malfunction symptoms in the chart and then taking the action indicated in the Corrective Measures column.

4. Troubleshoot the Range Finding System without the Control Indicator (ref. para. 14-6, TM 5840-298-35).

5. After completing troubleshooting procedure, turn OFF and disconnect all equipment and cables.

6. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-209-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

(continued)

TASK — Continued

UNIT REPAIR SOP

TECH II Lesson No.

TASK:

Troubleshoot and repair the Range Finding System of the AN/PPS-5(A) Radar Set.

c. Bench service components of the Range Finding System.

CONDITIONS:

A Block 500 Gate Generator and a Block 2900 Range Amplifier will be available.

STANDARDS:

You must perform the following general procedures when bench servicing the components in the Range Finding System:

1. Review and verify information on DA Form 2407.
2. Set up the required test equipment.
3. Connect the component for bench servicing.
4. Bench service the component, following all notes.
5. Remove and replace malfunctioning parts.
6. Bench adjust and test the component following repair.
7. For specific procedures for each component see para. from TM 11-5840-298-35, referenced below.
   a. Block 500 Gate Generator, Chap. 14, Sec. VI, para. 14-22 - 14-35.
   b. Block 2900 Range Amplifier, Chap. 14, Sec. VII, para. 14-29 - 14-35.
8. Complete DA Form 2407.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the Range Finding System of the AN/PPS-5(A) Radar Set.

b. Remove and replace components of the Range Finding System.

CONDITIONS:

One or more components of the Range Finding System will have been identified as needing to be removed for bench servicing or replacement.

STANDARDS:

You must:

1. Review and verify condition on DA Form 2407, making notes on additional symptom information.

2. To remove and replace components of the Range Finding System refer to the para. in TM 5840-298-3T, referenced below:

   a. For Block 500 Gate Generator, para. 14-8.

   b. For Block 2100 A-Display Assembly, para. 14-9.

   c. For Block 2900 Range Amplifier, para. 14-10.

3. Complete DA Form 2407 and return repaired set to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-70. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the Range Finding System of the AN/PPS-5(A) Radar Set.

d. Adjust and align the Range Finding System.

CONDITIONS:

The radar set will be located at a test site that has a spinning radar target at a range of 250± 1 meters.

STANDARDS:

You must perform the following procedure:

1. Review and verify information on DA Form 2407.

2. Realign the Range Counters and Delay Lines, 23601 and 23603, in the Control Indicator, following either a. or b. below:

   a. When the deviation error is marked on the Delay Line, follow procedure in para. 14-12.1, TM 5840-298-35.

   b. When the deviarion error is NOT marked on the Delay Line, follow procedures in para. 14-14.1, TM 5840-298-35.

3. Align the Range Counters and Delay Lines, 23601 and 23603, in the Control Indicator, para. 14-13, TM 5840-298-35.

4. Re-align the Range Counter and Delay Line, 21301, in the Receiver-Transmitter, by following either a. or b. below:

   a. When the deviation error is marked on the Delay Line, follow procedures in para. 14-12.2, TM 5840-298-35.

   b. When the deviation error is NOT marked on the Delay Line, follow procedures in para. 14-14.3, TM 5840-298-35.

5. Align the Range Counter and Delay Line, 21301, in the Receiver-Transmitte para. 14-14, TM 5840-298-35.

6. Complete DA Form 2407.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

(continued)

TASK — Continued.

TM-38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP.

TEC II Lesson No.

TASK:

Troubleshoot and repair the Range Finding System of the AN/PPS-5(A) Radar Set.

e. Field test the Range Finding System.

CONDITIONS:

A complete radar set will be set up as indicated in TM 11-5840-298-11, and available at a field site that has rotating target simulators positioned. Radar target RR-95A/TPS 21 (Radar Target) TM 11-5840-229-15.

STANDARDS:

You must perform the following procedures:

1. Check the accuracy of the Range Finding System of the entire radar set, para. 14-17, TM 5840-298-35.

2. Check the accuracy of the Range Finding System of the radar set without the Control Indicator, para. 14-18, TM 5840-298-35.

3. Check the accuracy of the Range Gates of the entire radar set, para. 14-19, TM 5840-298-35.

4. Check the accuracy of the Range Gates of the radar set without the Control Indicator, para. 14-20, TM 5840-298-35.

5. Check the Range Gate Markers of the radar set, para. 14-21, TM 5840-298-35.

6. Complete DA Form 2407.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP.

TEC II Lesson No.

TASK:

Troubleshoot and repair the target indicator system of the AN/PPS-5(A) Radar Set.

a. Troubleshoot the A-Display assembly and boxcar and audio amplified of the Target Indicator System.

CONDITIONS:

A radar set will be set up and troubleshooting based on starting procedures will have been completed. A trouble will have been sectionalized to the target indicator system.

STANDARDS:

You must perform the following steps:

1. Review and verify information on DA Form 2407 (TM 38-750).
2. Troubleshoot the target indicator system by performing necessary target indicator checks with the control indicator according to the following procedures (ref. Para. 15-6, Target indicator system troubleshooting chart, TM 11-5840-298-35):
   a. In the SYMPTOM column of the Chart, find the symptom that describes the Control Indicator System, A-Display Assembly malfunction observed.
   b. Follow the CORRECTIVE MEASURES procedure opposite the Symptom, always starting with step one of the procedure opposite the symptom.
   c. After each step of a Corrective Measure procedure has been performed, check to see if the symptom has been remedied. If it has NOT, proceed to the next step.
   d. If the trouble has not been located after completing checks with the indicator system, proceed to the chart in Para. 15-7, Target indicator system troubleshooting chart for radar without control idnicator, TM 11-5840-298-35.
3. Turn OFF and disconnect all equipment and cables and return them to proper storage area.
4. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to the using unit if all malfunctions have been corrected and no additional testing is required.

(continued)

TASK NO. -- Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the target indicator system of the AN/PPS-5(A) Radar Set.

b. Troubleshoot the B-Display assembly and the Rgf subassembly of the target indicator system.

CONDITIONS:

A radar set will be set up and troubleshooting based on starting procedures will have been completed. A trouble will have been sectionalized to the target indicator system.

STANDARDS:

You must perform the following steps:

1. Review and verify information on DA Form 2407 (TM 38-750).
2. Troubleshoot the Target Indicator System by performing necessary checks according to the following procedures (ref. Para. 15-6, Target indicator system troubleshooting chart, TM 11-5840-298-35):
   a. In the SYMPTOM column of the chart, find the symptom that describes the B-Display malfunction observed.
   b. Follow the CORRECTIVE MEASURES procedure opposite the SYMPTOM, always starting with the first step of the procedure opposite the Symptom.
   c. After each step of CORRECTIVE MEASURES procedure has been performed, check to see if the Symptom has been remedied. It it has NOT, proceed to the next step.
   d. If the trouble has not been located after completing checks with the control indicator, proceed to the chart in Para. 15-7, Target indicator system troubleshooting chart for radar without control indicator, TM 11-5840-298-35.
3. Turn OFF and disconnect all equipment and cables and return them to proper storage area.
4. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to using unit if all malfunctions have been corrected and no additional testing is required.

TASK NO. — Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the target indicator system of the AN/PPS-5(A) Radar Set.

c. Remove and replace components of the target indicator system.

CONDITIONS:

A radar set will be set up and troubleshooting based on starting procedures will have been completed. A trouble will have been sectionalized to the target indicator system. Tasks 6a and 6b must have been performed before starting this task. One or more parts will have been identified as malfunctioning or requiring additional testing.

STANDARDS:

You must perform the following steps in sequence:

1. Review and verify conditions stated on DA Form 2407 (TM 38-750); make any additional remarks on troubles found and use the information as a guidance in troubleshooting the system.
2. For removal and replacement of Target Indicator components, follow the procedures referenced below for each component (TM 11-5840-298-35):
   a. Block 400 Boxcar and Audio Amplifier, Para. 15-9, Removal and replacement of Block 400 boxcar and audio amplifier, and Para. 15-29, Removal and replacement of parts.
   b. Block 2100 A-Display assembly, Para. 15-10, Removal and replacement of block 2100 A-Display.
   c. Block 2200 B-display assembly, Para. 15-11, Removal and replacement of block 2200 B-display assembly.
   d. Block 2600 Rgf Assembly, Para. 15-13, Removal and replacement of Block 2600 Rgf Subassembly.
   e. Block 2700 Rgf Assembly, Para. 15-12, Removal and replacement of block 2700 Rgf assembly.
   f. PHONE jack checks J13 and J14 (replace as necessary), Para. 15-7,
3. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) radar set to using unit. If required, testing on the whole system should be completed before release of equipment.

TASK NO. - Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tools Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot and repair the target indicator system of the AN/PPS-5(A) Radar Set.

d. Bench service the components in the target indication system of the AN/PPS-5(A) radar set.

CONDITIONS:

Complete Tasks 6a and 6b before statting this procedure. Components requiring bench servicing and removed from an AN/PPS-5(A) radar set will be available.

STANDARDS:

You must perform the following general procedures when bench testing components of the target indication system:

1. **Review and verify the information on DA Form 2407 (TM 38-750).**
2. **Set up the required test equipment.**
3. **Connect the component for bench servicing.**
4. **Bench service the component following all notes.**
5. **Remove and replace all malfunctioning parts.**
6. **Bench adjust and test the component.**
7. **For specific procedures for each component see paragraphs from TM 11-5840-298-35, referenced below:**

   a. **Block 400 Boxcar and audio amplifier step-by-step troubleshooting Chart, Section VI, Paragraphs 15-25 through 15-30.**

   b. **Block 2100 A-Display assembly, Section VII, Paragraphs 15-34, 15-35, and 15-35.1, Block 2100 A-Display assembly step-by-step troubleshooting chart, and Para. 15-36.**

   c. **Block 2200, B-Display wssembly, Section VIII, Paragraphs 15-42, 15-43 (Block 2200 B-display assembly step-by-step troubleshooting chart), and Para. 15-46.**

   d. **Block 2600, Rgf Assembly, Paragraphs 15-58 and 15-59.**

   e. **Block 2700 Rgf Assembly, Section IX, Paragraph 15-52.**

   f. **Bench servicing A-Scope, B-Scope, and Headphones, Section XI, Paragraphs, 15-63, 15-65, and 15-66.**

TASK NO. — Continued

8. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) radar set to using unit. If required, testing on the whole system should be completed before release of equipment.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot the antenna positioning system of the AN/PPS-5(A) radar set.

a. Troubleshoot the antenna positioning system.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON.

STANDARDS:

You must perform the following steps:

1. Prepare the antenna positioning system for troubleshooting by:
   a. Setting up and connecting all required test equipment, ref. Para. 16-4 and Para. 16-5 (without control indicator) TM 11-5840-298-35.
   b. Set the controls and turn the equipment ON as specified in Para. 16-2, TM 11-5840-298-35.
   c. After a 5-minute warm-up period, reset external power output to 24 Volts.
2. Review and verify information on DA Form 2407 (TM 38-750) by performing test (ref. Para. 16-2, TM 11-5840-298-35), and make additional symptom information notes to use as guidance in troubleshooting.
3. Troubleshoot the Antenna Positioning System (Para. 16-4, Antenna positioning system symptom troubleshooting chart for complete AN/PPS-5(A) Radar Set, and Para. 16-5, Antenna Positioning system symptom troubleshooting chart for AN/PPS-5(A) without control indicator, TM 11-5840-298-35) according to the following procedures:
   a. In the SYMPTOM Column of the chart find the symptom that describes the radar set malfunction observed.
   b. Follow the CORRECTIVE MEASURES procedure opposite the SYMPTOM always starting with the first step of the procedure opposite the symptom.
   c. After each step of a CORRECTIVE MEASURES procedure has been performed, check to see if the symptom has been remedied. If it has NOT, proceed to the next step.

(continued)

TASK NO. -- Continued

4. Turn OFF and disconnect all equipment and cables, and return them to proper storage area if NO additional tests are to be performed.

5. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to the using unit if no additional tests are required.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot the antenna positioning system of the AN/PPS-5(A) radar set.

b. Remove and replace the antenna positioning system components.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON.

STANDARDS:

You must perform the following steps in sequence:

1. Review and verify conditions stated on DA Form 2407 (TM 38-750); make any additional remarks on troubles found and use information as a guidance in troubleshooting the system.
2. For removal and replacement of antenna positioning system components, follow the procedures referenced below for each component (TM 11-5840-298-35):
   a. Block 900 Motor Control, Para. 16-7,
   b. Resistor and Diode Assembly E3108, Paragraphs 16-8, 16-30, and 16-35,
   c. Block 1500 Azimuth, Para. 16-49,
3. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) Radar Set to using unit. If required, complete testing on replaced parts and complete system.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

(continued)

TASK NO. -- Continued

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK:

Troubleshoot the antenna positioning system of the AN/PPS-5(A) radar set.

c. Bench service the antenna positioning system.

CONDITIONS:

All steps set out in TASK 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON. Components requiring bench servicing and removed from an AN/PPS-5(A) radar set will be available.

STANDARDS:

You must perform the following general procedures when bench testing components of the antenna positioning system.

1. Review and verify the information on DA Form 2407 (TM 38-750).
2. Set up the required test equipment.
3. Connect the components for bench servicing.
4. Bench service the component following all notes.
5. Remove and replace all malfunctioning parts.
6. Bench adjust and test the component.
7. For specific procedures for each component see paragraphs from TM 11-5840-298-35, referenced below:
   a. Block 900 Motor Control, Section V, Para. 16-16, 16-26, and 16-26.1.
   b. Block 1200 relay control,
   c. Block 2800 Azimuth counter, Section V and X1, Para. 16-16 and 16-44.
   d. Block 2400 Azimuth Servo Generator and amplifier assembly, Section X, Para. 16-16, 16-39, and 16-40.
   e. Block 1600 Azimuth counter assembly in rec-xmtr, Section V, Para. 19-15.
   f. Block 1700 Commutator Assembly, Section , Para. 16-14 and 19-15.

(continued)

TASK NO. -- Continued

7. g. Resistor and diode assembly E3108, Section VIII, Para. 16-29.

   h. Component Board E3602, Section IX, Para. 16-34.

   i. Block 1500 Azimuth Drive, Section XII, Para. 16-48.

   j. Lampholder Assembly E1801, Section XIII, Para. 16-50.

   k. Servo loop test, Section V, Para. 16-16.

8. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to using unit, if no additional tests are required.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

Task 9d, MOS 26C

TASK:

Troubleshoot the antenna positioning system of the AN/PPS-5(A) radar set.

d. Adjust, align, and test the antenna positioning system.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON. Components requiring bench servicing and removed from an AN/PPS-5(A) radar set will be available. The antenna positioning system in the AN/PPS-5(A) radar set has been repaired and reassembled, but not finally adjusted and aligned.

STANDARDS:

You must perform the following procedures:

1. Set up required test equipment, Para. 16-10, 16-18, 16-22, 16-37, 16-42, 16-48, and 16-50, TM 11-5840-298-35.
2. Adjust and align the following components during bench servicing:
   a. Block 2400 Azimuth Servo Generator and Amplifier Assembly, Para. 16-11, TM 11-5840-298-35.
   b. Block 900 Motor Control, Paragraphs 16-12, and 16-26.1, TM 11-5840-298-35.
   c. Syncho Transmitter T1601 with control transformer T2801, Para. 16-13, TM 11-5840-298-35.
   d. Azimuth Sweep Potentiometer R1703, Para. 16-14, TM 11-5840-298-35.
3. Test the Servo Loop of the antenna positioning system, Para. 16-16, TM 11-5840-298-35.
4. Perform Direct Support Testing of the Antenna Positioning System, Section VI, Paragraphs 16-17 through 16-20, TM 11-5840-298-35.
5. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to using unit if no additional tests are required.

(continued)

Task Id, M05736

TASK NO. — Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

TASK NO. -- Continued

3. c. After each step of a CORRECTIVE MEASURES procedure has been performed, check to see if the Symptom has been remedied. If it has NOT, proceed to the next step.

4. Turn OFF and disconnect all equipment and cables and return them to proper storage area if no additional testing is required.

5. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) radar set to using unit.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407.

UNIT REPAIR SOP

TEC II Lesson No.

Task 86, 1105.26C

TASK:

Troubleshoot and repair the power supply system.

b. Remove and replace power supply components.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON. Task 8a must be completed before starting this operation. WARNING: HIGH VOLTAGE is present when power is turned ON (+2000V to -2000V).

STANDARDS:

You must perform the following steps in sequence:

1. Review and verify conditions stated on DA Form 2407 (TM 38-750); make any additional remarks on troubles found, and use the information as a guidance in troubleshooting the system.
2. For removal and replacement of Power Supply System components, follow the procedures referenced below for each component (TM 11-5840-298-35):
   a. Block 1200 Relay Control, Para. 17-12,
   b. Block 2300 Power Converter, Para. 17-10, 17-33
   c. Block 3300 Interlock Relay Board Assembly, Para. 17-11, 17-40
   d. Block 700 Radar Power Converter, Para. 17-9, 17-26.
   e. Filter Choke L3601, Para. 17-13.
   f. Transistor and Potentiometer, Para. 17-47.
   g. Power Supply, Para. 17-54.

(continued)

TASK NO. -- Continued

3. Complete DA Form 2407 (TM 38-750) and return repaired AN/PPS-5(A) Radar Set to using unit. If required, complete testing on replaced parts and system.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

ASSALT 1105260
Task 8 e

TASK:

Troubleshoot and repair the power supply system.

c. Bench service the power supply system.

CONDITIONS:

Steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 17, TM 11-5840-298-35, must be reviewed. Components requiring bench servicing will have been removed from an AN/PPS-5(A) Radar Set and will be available.

STANDARDS:

You must perform the following general procedures when bench testing components of the Power Supply System:

1. Review and verify the information on DA FORM 2407 (TM 38-750).
2. Set up the required test equipment.
3. Connect the component for bench servicing.
4. Bench service the component following all notes.
5. Remove and replace all malfunctioning parts.
6. Bench adjust and test the components.
7. For specific procedures for each component see Paragraphs from TM 11-5840-298-35 referenced below:
   a. Block 700 Power Converter, Section V, Paragraphs 17-21 thru 17-25.
   b. Block 2300 Power Converter, Section VI, Paragraphs 17-28 thru 17-34.
   c. Block 3300 Interlock Relay Assembly, Section VII, Paragraphs 17-35 thru 17-41.
   d. Block 1200 Relay Control, Section VIII, Paragraphs 17-42 thru 17-48.
   e. Power Supplies [PP-4450A/PPS-5, PP-4450/PPS-5, and PP-440B/PPS-5], Section IX, Paragraphs 17-49 thru 17-58.

TASK NO. — Continued

8. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to using unit. If required, complete testing on replaced parts and system.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

Task 2d, MOS 26C

TASK:

Troubleshoot and repair the power supply system.

d. Adjust and align the power system.

CONDITIONS:

All steps set out in Task 1, Troubleshooting based on starting procedures on the AN/PPS-5(A) Radar Set, must be used to perform this operation. WARNINGS in Chapter 15, TM 11-5840-298-35, must be reviewed. Use reference data listed in Chapter 15, Section I, Target indicator system troubleshooting and repair, TM 11-5840-298-35, to locate sub-assemblies, schematic diagrams, etc. WARNING: HIGH VOLTAGE 2000V and 3000V are present in the TARGET INDICATOR SYSTEM when RADAR is ON. Task 8c must be completed before starting this operation. WARNING: HIGH VOLTAGE is present when power is turned ON (+2000V to -2000V). Components requiring bench servicing and removed from an AN/PPS-5(A) Radar Set will be available. The Power Supply System from and AN/PPS-5(A) Radar Set has been repaired and reassembled, but not finally adjusted and aligned.

STANDARDS:

You must perform the following procedures:

1. Set up required test equipment, ref. Para. 17-5, 17-15, 17-22, 17-29, 17-36, 17-43, and 17-50, TM 11-5840-298-35.
2. Adjust and align the following components during bench servicing:
   a. Power Supply System, Para. 17-2, TM 11-5840-298-35.
   b. Block 700 Power Converter, Para. 17-27, TM 11-5840-298-35.
   c. Block 3300 Interlock Relay Assembly, Para. 17-41, TM 11-5840-298-35.
3. Test the Power System [Direct Support], Section IV, Para. 17-16, 17-17, 17-18, 17-19, and 17-20, TM 11-5840-298-35.
4. Complete DA Form 2407 (TM 38-750) and return the repaired AN/PPS-5(A) to the using unit. If required, complete testing on replaced parts and system.

(continued)

TASK NO. -- Continued

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA FORM 2407

UNIT REPAIR SOP

TEC II Lesson No.

Task 10a, MOS 36C

TASK:

Complete testing and alignment of Radar Set AN/PPS-5(A).

a. Perform system testing on Radar Set AN/PPS-5(A).

CONDITIONS:

An AN/PPS-5(A) Radar Set that has been either out of operation for a prolonged period, or that has been extensively repaired will be available.

STANDARDS:

You must perform the following steps in sequence:

1. Set up all required test equipment, Chapter 18, TM 11-5840-298-35.
2. Perform initial control settings on the Radar Set AN/PPS-5(A), ref. Section II, Operation under usual conditions, Para. 3-3, Preliminary control settings, TM 11-5840-298-12).
3. Perform operational checks, ref. Chapter 4, Para. 4-5, Operation's daily preventive maintenance checks and services chart, TM 11-5840-298-12.
4. Perform complete system testing on Radar Set AN/PPS-5(A), ref. Para. 18-2, Radar Set AN/PPS-5 complete testing, TM 11-5840-298-35.
5. Turn OFF and disconnect all equipment and cables. Set up for bench testing in next task.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

DA Form 2407.

DA Form 2408-5.

UNIT REPAIR SOP

TEC II Lesson No.

APPENDIX D

EVALUATION MANUAL

Performance Test
Troubleshooting

EVALUATION MANUAL

PERFORMANCE TEST

TROUBLESHOOTING

INTRODUCTION

GENERAL INSTRUCTIONS TO EVALUATOR

INTRODUCTION

GENERAL INSTRUCTIONS TO EVALUATOR

This material has been assembled for use by individuals responsible for the administration of the Performance Tests for Evaluating Skill Proficiency in MOS 26C. Testing the performance of maintenance job tasks requires considerable preparation. This material is provided as an aid to that preparation. Read through all the materials in the manual before beginning your preparation.

The Performance Tests are made up of tasks found on-the-job and use actual equipment, tools, and materials. This manual is divided into sections, each of which provides specific instructions for the preparation, administration and scoring of one Performance Test.

Part I of each section includes the performance objective with a statement of the task to be performed, the job conditions under which it is to be performed and the standards to which it is to be performed.

Part II includes a list of references for the doctrinal procedures, warnings, and detailed instructions for performing the task. These references are provided for the Evaluator's information only. The Examinee may or may not use these procedures.

Part III provides detailed instructions to the Test Administrator and Evaluator. These include:

1. The purpose of the test.
2. A description of the test conditions.
3. A list of the equipment, tools and materials needed to administer the test.
4. A description of the facilities.
5. Personnel needed to administer the test and the administrative procedures to include information necessary to insure standardization of test administration.

6. The instructions to the Examinee. These instructions will be read to the Examinee before the test is started.
7. The scoring form with scoring instructions.

PREPARATION FOR THE TEST

To prepare for each test, you must accomplish the following:

1. Assemble all required equipment, materials and tools, including forms and pencils.
2. Set up the test station as described in the test conditions.
3. For those tests where the Examinee must isolate a malfunction, you must insert the designated faulty component before the Examinee arrives for testing.
4. Plan the order in which each test will be administered to each Examinee.

ADMINISTRATION OF THE TEST

To administer the test, you must perform the following:

1. Read the instructions to the Examinee after he has arrived at the test station.
2. Start the test by saying GO, and begin timing of the test.
3. Observe the Examinee's performance and make the necessary recording of information.
4. Stop the Examinee if he is about to initiate an action that will constitute a hazard to himself or to the equipment.
5. At the conclusion of the test send the Examinee to the next test station.
6. Complete the score sheet and prepare for the next test.

PART 1

PERFORMANCE OBJECTIVE

TROUBLESHOOT AND REPAIR THE AN/PPS-5(A) RADAR SET

TASK:

Troubleshoot the AN/PPS-5(A) radar.

CONDITIONS:

Given: An AN/PPS-5(A) radar set that is not operating properly, a DA FORM 2407 with symptom information, all necessary tools, test equipment and documents.

Task will be accomplished at a work bench set up for bench servicing with adequate lighting and working space. All safety precautions will be observed.

STANDARDS:

You must perform the following procedures:

1. Verify the information on DA FORM 2407 by performing the necessary checks.
2. Identify the system which contains the faulty component responsible for the malfunction symptom information.
3. Identify the sub-assembly within the system which contains the faulty component.
4. Identify the stage within the sub-assembly which contains the faulty component.
5. Identify the faulty component.
6. Operate all test equipment correctly.
7. Use safe operating procedures at all times.
8. Complete the test in one hour.

REFERENCES:

TM 11-5840-298-12. Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radar Set AN/PPS-5.

TM 11-5840-298-35. DS, GS, and Depot Maintenance Manual, Radar Set AN/PPS-5(A).

TM 38-750. The Army Maintenance Management System (TAMMS).

TMs for Test Equipment

DA FORM 2407

UNIT REPAIR SOP

PART 2

DETAILED TASK PROCEDURES

DETAILED TASK PROCEDURES

The specific faulty components for this troubleshooting problem are the CR101 and CR102 Crystals located in the Block 100 IF Signal Mixer.

The following paragraphs from TM 11-5840-298-35 describe the doctrinal troubleshooting procedures necessary to identify the CR101 and CR102 Crystal as faulty:

Chapter 10, Paragraph 10-6.

Chapter 13, Paragraphs 13-1 through 13-13.

PART 3

EVALUATOR INSTRUCTIONS

FOR ADMINISTRATION AND SCORING

PERFORMANCE TESTS FOR TROUBLESHOOTING

The Performance Test for troubleshooting the AN/PPS-5(A) requires that the Examinee successively isolate a malfunction to a system, sub-assembly, stage, and faulty component. The specific procedures, tools and test equipment used in troubleshooting will vary with Examinee. The evaluation of troubleshooting performance requires the observation of the end result of sets of activities, Examinee's use of the test equipment he selects to use, and whether or not Examinee follows safe operating procedures.

TASK

For this Performance Test the Examinee must troubleshoot the AN/PPS-5(A) radar set and isolate the malfunction as follows:

1. System -- Target Indicator
2. Sub-assembly -- Block 100
3. Stage -- IF Signal Mixer
4. Component -- CR101 and CR102 Crystals (open)

The test requires that the Examinee demonstrate:

1. Skill and speed in obtaining symptom information by using various pieces of test equipment.
2. Interpretation of symptom information leading to the isolation of a malfunction to succeeding levels of equipment sections.
3. The use of safe operating procedures.

TEST CONDITIONS

Site--this test will be conducted at a work bench normally used for electronic maintenance activities. Tools and equipment will be arranged as they would typically be found on the job.

Lighting--the bench will be well lighted so all parts are easily visible.

Uniform--the soldier will be dressed in the standard duty uniform.

EQUIPMENT, TOOLS AND MATERIALS

The following will be available at the work bench:

AN/PPS-5(A) radar set with the CR101 and CR102 Crystals open.

Dummy load
Oscilliscope
Power Supply
Tool Box
DA FORM 2408 (blank)
TM 11-5840-298-35
TM 11-5840-298-12
Pulse generator (two)
Test facilities kit MK-980
Audio Oscillator
VTVM
TMs for test equipment
A DA FORM 2407 with the following information:
No target received
No audio in headset

In addition, you must have a clipboard, score sheets, a pencil and a stop watch.

FACILITIES AND TEST PERSONNEL

Facilities--the test station should be in a facility normally used for electronic maintenance activities. If not, make the following preparations:

1. Ground the work bench.
2. If the building is metal, it must be grounded.
3. In addition to normal building power supplies, make available 6 volt DC and 24 volt DC power supplies.
4. Place a rubber mat on the floor in front of the work bench that extends the entire length of the bench.
5. Place electronic emergency and first aid supplies near the work bench for easy access.
6. Place a fire extinguisher in the room.

An area must be available where Examinees can wait that is out of sight and hearing of the test station. Examinees will be required to return to this area after each test while the test station is prepared for the next administration.

Personnel--One test administrator will be required. His duties will be:

1. Before the Examinee(s) arrive for testing, brief the Evaluators and observe their preparation of their test station(s). Assure that all required equipment and materials have been assembled. Verify all malfunction symptom information required at specific test stations. Position the Evaluators for their most advantageous observation of Examinee(s) during testing.
2. When the Examinee(s) arrives, brief him on how the tests will be administered.
3. During the test, observe the administrative procedures, making note of gross administration errors that would invalidate test results.
4. After the test, observe that Examinee(s) return to the waiting area. Collect the score sheets while the Evaluator(s) prepares his (their) test station(s) for the next administration.

One Evaluator [who has had at least one year of experience in the maintenance of electronic equipment and is familiar with the AN/PPS-5(A) radar set and its test equipment] will be required for each test station. His duties will be:

1. Before the test, read through the evaluation manual. Assemble all equipment, tools and materials. Check that the facilities meet safety requirements.
2. Before the Examinee arrives, prepare the test station to meet the test conditions. Insert the faulty component(s) to create the specified malfunction symptom information.
3. When the Examinee(s) arrive(s) at your station, read the instructions to him. Answer any questions pertaining to test administration, but do not tell him how to perform the task. Any questions about the task should be answered, "Perform the task as you would do it on-the-job."
4. During the test, observe and time the Examinee's performance. STOP him at any time he is about to initiate an action that will constitute a hazard to him or to the equipment. Explain the hazard before allowing him to proceed. Timing will continue and will not be stopped.
5. When the test is completed, send the Examinee back to the waiting area.

INSTRUCTIONS TO EXAMINEE

The Test Administrator will read the following instructions to the Examinee(s) when he (they) arrive(s) at the waiting area:

"Today you are to be evaluated on how well you do your job. The evaluation procedures require you to perform various tasks taken from your job. The specific task will be explained by the Evaluator at each test station. You may ask questions about the test administration procedures, but not about the task. When you are told 'GO', perform the task as you would on your job. Report to the Evaluator any information he instructs you to provide. If you are about to initiate an action that the Evaluator thinks will constitute a hazard to you or to the equipment, he will STOP you, explain the hazard, and then allow you to proceed. For each such violation of safe operating procedures, or improper use of test equipment, you will receive penalty points. After completion of each test you will return to this waiting area while the test station is being prepared. Are there any questions? Alright, go to your first test station."

The Evaluator will read the following instructions to the Examinee when he arrives at the test station:

"At this station you will be tested on your ability to troubleshoot the AN/PPS-5(A) radar set. As you isolate the malfunction to the system, verbally report the system to me in which you think the malfunction is located. Also report the sub-assembly and stage as you isolate the malfunction further. Finally, report the component and its fault that is causing the malfunction symptom information. Use any of the materials, tools and equipment that you need. I will STOP you at anytime I think you are about to initiate an action that will constitute a hazard to you or

to the equipment. You will be scored on your isolation of the malfunction(s) to the system, sub-assembly, stage, and component. You will also be evaluated on your procedures in terms of safe operation and correctness of use of any test equipment. You will have one hour to complete the test. Do you have any questions? Alright, 'GO'."

SCORING INSTRUCTIONS FOR EVALUATOR

Electronic maintenance technicians tend to develop their own unique sets of troubleshooting procedures as they gain experience with specific electronic equipment. Therefore, checklists of specific procedures are not used as standards of performance. Instead, the results of successive sets of activities are evaluated.

ITEM I on the score sheet is for scoring the Examinee's ability to isolate the malfunction. If the Examinee correctly identifies the successive locations of the malfunction indicated on the score sheet, make a check in the column headed CORRECT. If his identifications are wrong, check the INCORRECT column.

ITEM II on the score sheet is for scoring the Examinee in terms of correct use of test equipment. Check whether or not the Examinee used each piece of equipment. For each piece of equipment used, check whether or not he commited the errors that are listed.

ITEM III on the score sheet is for scoring the Examinee in terms of safe operating procedures. Check whether or not he committed the safety violations listed.

STOP the Examinee after one clock-hour if he has not isolated the malfunction to the component prior to that time.

TEST NO. 5 TROUBLESHOOTING DATE _____

EXAMINEE _____ SOCIAL SECURITY NO. _____

RANK _____ TIME STARTED _____

EVALUATOR _____ TIME FINISHED _____

TASK: TROUBLESHOOT THE AN/PPS-5(A) RADAR SET.

I. Isolation of Malfunction.

CORRECT	INCORRECT	ACTIONS
		1. Verified symptom information.
		2. Isolated malfunction to Receiver Transmitter.
		3. Isolated malfunction to Block 100 Sub-assembly.
		4. Isolated malfunction to IF Signal Mixer
		5. Identified CR101 and CR102 Crystals as open.

GRADE: ___ SATISFACTORY

___ UNSATISFACTORY

Instructions:

1. Check whether actions were correct or incorrect.
2. Check satisfactory if all actions were correct.
3. Check unsatisfactory if one or more actions were incorrect.

II. Equipment Use.

A. VTVM USED ___ NOT USED ___

YES	NO	ACTION
		A1. Measures resistance with equipment power turned on.
		A2. Used incorrect sequence of scale settings for measuring voltage. (Should go from high to low scales.)
		A3. Did not zero the meter.
		A4. Used probes in a sloppy manner--danger of shorting out other components.
		A5. Other (Specify) _____ _____

(continued)

II. Equipment Use.

B. OSCILLOSCOPE USED ___ NOT USED ___

YES	NO	ACTION
		B1. Incorrect operation.

C. WAVEFORM GENERATOR USED ___ NOT USED ___

YES	NO	ACTION
		C1. Damaged cables.
		C2. Did not refer to TM 11-5840-298-35 for set up.

D. OSCILLATOR USED ___ NOT USED ___

YES	NO	ACTION
		D1. Damaged Cables.
		D2. Did not refer to TM 11-5840-298-35 for set up.

E. TEST FACILITIES KIT (MK 980) USED ___ NOT USED ___

YES	NO	ACTION
		E1. Damaged connector pins.
		E2. Connected-Disconnected cards while Kit was turned on.
		E3. Used improper sequence in turning the Kit ON or OFF.
		E4. Used improper tools when removing cards from Kit.

F. DUMMY LOAD USED ___ NOT USED ___

YES	NO	ACTION
		F1. Incorrect alignment when connected.

GRADE: ___ SATISFACTORY

___ UNSATISFACTORY

(continued)

II. Equipment Use.

Instructions:

1. Check satisfactory if all actions have been checked "NO".
2. Check unsatisfactory if Action #A1 was checked "YES".
3. Check unsatisfactory if three or more of Actions A2 through F1 have been checked "YES".

III. Safe Operating Procedures.

YES	NO	ACTION
		1. Hands placed in Block 700 [+300V, +110V] or Block 2300 [+2000V, -2000V] Power Converter when Radar Set is ON.
		2. ONE HAND RULE not used. [One hand on test-probe, one hand in your pocket, or behind your back] when testing voltage in A-Scope and B-Scope Display Circuits [+2000V is present when power and equipment switches are ON].
		3. Head and/or body closer than 2 feet in front of the antenna for more than 10 minutes while Radar Set is transmitting [High frequency electromagnetic radiation can cause fatal internal burns and eye damage].
		4. Not discharging A- and B-Scope after turning OFF power and before working in high voltage circuit.
		5. Fingers in contact with gears of the Antenna System.
		6. Improper Power Supply used [Severe damage to the Radar Set may result].
		7. Power not removed before removing component from Radar Set.
		8. Test equipment not grounded to Radar Set.
		9. Battery Electrolyte not removed or neutralized from skin and clothing by flushing with water.
		10. Use of metalic tools where non-metalic tools are called for in making adjustments on the Radar Set.
		11. Not using due caution when operating equipment, such as setting test equipment, tool box, etc. in the path of antenna movement; allowing cables to become entangled, etc.
		12. Holding test equipment probe by metal.
		13. Failing to discharge high voltage circuits prior to taking measurements.

(continued)

III. Safe Operating Procedures.

GRADE: ___ SATISFACTORY

___ UNSATISFACTORY

Instructions:

1. Check "YES" for each of the actions committed by the Examinee.
2. Check satisfactory if no more than three of the actions are checked "YES".
3. Check unsatisfactory if more than three actions are checked "YES".